# USE OF MOLASSES IN THE FEEDING OF FARM ANIMALS

SCOTT

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Use of molasses

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# *Use of Molasses in the Feeding of Farm Animals*

REVIEW
And
ANNOTATED BIBLIOGRAPHY

Compiled By
MILTON L. SCOTT, Ph.D.
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*Cornell University*

TECHNOLOGICAL REPORT SERIES
No. 9

SUGAR RESEARCH FOUNDATION, INC.
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*July, 1953*

## BIOGRAPHICAL NOTE

*DR. MILTON L. SCOTT was born in Tempe, Arizona, February 21, 1915. He obtained his Bachelor of Art's Degree from the University of California in 1937. The next five years were spent as a vitamin chemist in industry. In 1942, he took up graduate studies as a Fellow at Cornell University and received his Doctor of Philosophy Degree in 1945. Dr. Scott remained at Cornell, teaching and working in the Department of Animal Nutrition and Poultry Husbandry, where he has isolated various nutritional factors and studied other biochemical factors relating to poultry husbandry.*

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# FOREWORD

THE most important by-product of the sugar industry is blackstrap molasses. When the price of this commodity dropped precipitately from 36¢ per gallon to 4¢ the impact upon the sugar industry was immediate and unpleasant. Something obviously had to be done.

An analysis of the situation showed that two developments in the petrochemical industry were responsible. First, production of ethanol from ethylene had increased. Second, the market for ethanol had diminished because of increasing butadiene production from butane and butenes.

The obvious market for the excess molasses thus made available is in stock feed. The total molasses production of the world is small compared to the tonnage of stock feed required by the United States alone. The problem was and is how to expand this market rapidly. Before starting research in a field where so much has already been done, it is desirable to have the prior literature reviewed by an expert.

Sugar Research Foundation was fortunate in securing for this purpose the services of Professor Milton L. Scott who was going on sabbatical leave just at the right time. This volume is the result of Professor Scott's study of the literature. It will serve for years to come as a basis of future progress in the utilization of molasses in animal nutrition.

HENRY B. HASS
*President*
SUGAR RESEARCH FOUNDATION, INC.

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# REVIEW OF THE LITERATURE

## INTRODUCTION

The benefits resulting from the use of molasses in rations for farm animals have been discovered, lost in obscurity and rediscovered many times throughout the past one hundred and fifty years. Beet molasses was used to advantage in parts of France during the Napoleonic Era following an edict by Napoleon demanding the intensive planting of sugar beets in an effort to make France independent of imported sugar. During the latter half of the Nineteenth Century the use of molasses feeds became widespread throughout Europe. However, due in part to lack of experimental evidence concerning the nutritional value of molasses, and in part to misuse of molasses in the manufacture of molasses feeds containing a high percentage of peat or other materials of low digestibility, its use was not generally accepted by good livestock feeders.

As in the case of practically all progressive changes throughout history, the general acceptance of molasses in rations for livestock awaited endorsement by a recognized scientific leader of the times. Such an endorsement was forthcoming in the form of a review on the value of molasses feeds written by Otto Kellner (534) in 1909. Following this publication, many papers flooded the European literature praising the value of molasses in rations for farm stock. In America, even though Culley and Carson (36) in 1890 had suggested the beneficial effect of molasses in rations for fattening cattle, no great deal of attention was paid molasses until Lindsey (178) became convinced in 1905 that molasses had a definite feeding value for cattle.

The studies of Swanson and Tague (309), Reed and Fitch (305) and Hunter (283) in 1917 and 1918 demonstrated the value of molasses as a preservative for alfalfa silage, yet apparently little recognition of this fact was made until Elting (265) "rediscovered," 17 years later, that molasses is an excellent preservative for soybean silage.

Recent discoveries, led by the Pennsylvania (176, 180), Louisiana (194, 195, 196), Purdue (157, 158) and Iowa (161, 11) workers, promise new horizons in beef and dairy cattle feeding through the utilization of molasses as a palatability factor and as a rumen microbial stimulant in conjunction with inexpensive protein substitutes such as ammonium salts and urea and with low quality roughages such as cottonseed hulls, corn cobs and straw.

These developments enter only part way into the vast potential frontier presented to the feed manufacturer and livestock feeder in the form of the huge amounts of inexpensive molasses that are available for use in the feeding of farm animals. The groundwork has been laid for the use of molasses in rations for swine and poultry. One need only read the accounts of the research works which have been conducted in these fields to realize that great discoveries have been made here. The wealth of feeding possibilities in the fields of swine and poultry nutrition lie dormant, awaiting exploitation.

## MOLASSES IN THE FEEDING OF RUMINANTS

**Molasses in Mixed Rations**—The results of the investigations on the use of molasses in rations for ruminants provide overwhelming evidence in support of its value for this purpose. In beef cattle investigations, rations containing molasses as a partial substitute for grains show results equivalent or superior to those obtained with similar rations without molasses in 66 of the 74 experimental studies. With dairy cattle, 31 of the 34 investigations show that body weight and milk production were maintained at equivalent levels or were increased upon substitution of molasses for a part of the grain portion of the ration. Similarly, in sheep and goats, 11 of the 12 experiments show molasses to be of value in rations for these species.

Only a few rules need be followed in making full use of molasses in rations for beef and dairy cattle: (1) In using molasses, it should be regarded largely as a source of highly digestible energy (215, 222, 478) and trace minerals, and should be used in rations which are well balanced in regard to other required nutrients. (2) Because molasses stimulates appetite, a proportionate increase in total ration, especially in protein supplement (76), should be provided when molasses is used (27, 535). (3) For best results, the level of molasses should be approximately 8% of the starter ration

for calves, and it should be increased gradually as the calves grow older (12, 13, 15, 66, 84, 95). For steers weighing 750-1000 pounds or more and for dairy cows, the level should be such as to provide in the neighborhood of 2 to 5 pounds of molasses per head daily (2, 4, 18, 26, 64, 81). As a general rule, best results are obtained when molasses is substituted for 25% to 50% (7, 9, 61, 82, 111, 112, 114) of the carbohydrate concentrate, with provisions being made to maintain adequate nitrogen intake either by supplying additional protein concentrate or by the use of urea or ammonium salts. It is important not to set the level of molasses so high as to cause scouring which results when the mineral content of the ration becomes excessive (4, 63, 79, 551).

For sheep and goats, these same rules apply except that the optimum levels of molasses appear to be in the order of 0.5 to one pound per head, daily (139).

The use of molasses in rations for ruminants has been shown to be advantageous in many ways: **(1)** It increases the palatability of practically all types of rations, especially those containing poor quality roughages such as cottonseed hulls, ground corn cobs and straw (3, 9, 115, 135, 140). **(2)** Its rich content of easily digestible energy is of immediate value to the animal itself, but in addition to this, molasses at proper levels has a marked beneficial effect upon the cellulose-splitting, protein-synthesizing and vitamin-synthesizing microorganisms in the rumen (6, 203, 210, 211, 221, 404, 405). (This may be the basis for the contention by Gerlaugh that molasses appears to contain an unknown growth factor required by growing cattle (27)). Studies have shown that pigs following cattle on rations containing molasses grow at a considerably faster rate than do pigs following cattle receiving similar rations without molasses (26, 32, 83). **(3)** Molasses at times appears to exert a tonic action, possibly due to its trace mineral content, which is beneficial to cattle and lambs and may be reflected in better health and in improved quality of the skin and hair (13, 94, 107, 145, 440). **(4)** In finely-ground corn fodder, a level of 10% molasses was found to practically eliminate all dust and 30% eliminated fine particles (3). This "binding" property of molasses is of great importance to those who desire to feed a concentrate mixture to cattle in the open under varying degrees of windy weather where a feed not containing molasses might blow away before being consumed. **(5)** At present the cost of molasses

is much less than the cost of the amount of cereal grain which it will replace. Under unfavorable conditions, 100 pounds of molasses has been shown to replace approximately 75 pounds of corn or other grains; however, an average of all studies indicates that its grain replacement value is more nearly in the order of 85% (9, 60, 64, 75, 78, 86, 537, 555). (6) Due to the potassium present in molasses, the manure from animals receiving rations containing this material is more valuable than that from animals consuming rations without molasses (123).

**Molasses Feeds**—Because of the recognized value of molasses in livestock feeding and because of the fact that its physical nature is sometimes a deterrent to its widespread use, numerous methods have been devised to aid in the handling of molasses. The most common of these has been the mixing of molasses with a highly absorptive material to form a dry, non-sticky feeding material which can be handled in bags or in bulk form without the use of tanks.

Materials which have been found suitable for this use are: Finely ground bagasse, alfalfa meal, bran, beet pulp, palm nut meal, peanut hulls, sesame hulls, straw, chaff, dried blood, pulverized limestone, seed-beet litter, oat mill feed and corn-germ meal. Using a finely pulverized, dry material, a suitable mixture containing more than 50% molasses can be made. Such rations may have as much as 70% or more of digestible carbohydrates (153). On the other hand, the use in the past of such totally indigestible materials as peat, which not only has no feeding value but also decreases the digestibility of the rest of the ration (175), has been largely responsible for the prejudices which have built up against the feeding of molasses feeds.

Many ingenious molasses feeds have been devised. In one, small particles of fresh vegetable matter such as green alfalfa are treated with the hygroscopic molasses so as to withdraw water from the vegetable cells and impregnate them with molasses, whereupon the mixture is dehydrated (154). Another method involves the heating of molasses with agar agar or gelatin, producing a jelly-like material which can be handled easily (156). A mixture of 75% dried beet slices and 25% molasses has been pressed into briquets at a pressure of 120-150 atmospheres, yielding a product which not only is easily handled but also permits easy measuring at feeding time.

Upon being placed in water, the briquets fall apart and are consumed readily by cattle (187).

**Ammoniated Molasses, Molasses-Urea Mixtures and Rumen Digestion**—The fact that rumen microorganisms have the ability to convert ammonium salts, urea and other non-protein-nitrogenous compounds into bacterial protein, which is subsequently digested by the ruminant and may serve to furnish the needs of the animal for both essential and non-essential amino acids, has been known for some time (230, 231). However, full use of these non-protein-nitrogen materials has not been accomplished heretofore because of the extreme lack of palatability of such materials in rations for ruminants. Recently, this handicap has been overcome by a number of investigators through the discovery that molasses is so palatable to the animals that it masks the objectionable flavors from the non-protein nitrogenous compounds. The studies with ammonium salts and urea-molasses combinations have indicated, furthermore, that molasses is not only essential for the increasing palatability, but also acts to furnish the rumen microorganisms with minerals and sugar which are needed in order to initiate and to maintain rapid growth of the protein-synthesizing microorganisms (157, 158). Thus, since the same rumen conditions are required for the splitting of cellulose and for the synthesis of B-vitamins as are necessary for the synthesis of protein from non-protein-nitrogen compounds, the use of molasses, which is an inexpensive ingredient in itself, allows for a tremendous reduction in the cost of feeding ruminants by aiding in the utilization of inexpensive protein substitutes (NPN) and inexpensive carbohydrates such as corn cobs and straw.

Realizing that the utilization of such materials as ammonium salts, urea, corn cobs and straw is dependent upon the use of molasses, many new molasses feeds have been developed. In one of these, ammonia has been caused to react with the sugar in molasses to form a nitrogenous material having a protein equivalency of 15 to 30% (193). In another, a protein-mineral-vitamin supplement has been formulated together with molasses in such a way as to promote near-optimum growth of cellulose-splitting microorganisms so that full use can be made of such inexpensive roughages as corn cobs and straw (158).

A few precautions should be noted: (1) Non-protein-nitrogen

and low-quality roughages are of little or no value to the young calf or lamb until the rumen microbiological flora has become reasonably well developed. Knodt and associates (176) found that ammoniated molasses, fed as a replacement for the nitrogen of soybean meal and oats in the ration of Holstein bull calves could not be used before the calves were 12 weeks of age, and only in limited quantities from the 12th to the 16th week, but that thereafter it acted as a satisfactory substitute for these ingredients. (2) According to Mills and associates (226), for maximum growth of calves, a ration of roughage, molasses and urea must be supplemented with 3-5% of a more insoluble, but fermentable carbohydrate or insoluble protein, which can be provided by cereal grains or protein concentrates such as the oil meals. (This is being done in such successful feeding supplements as Purdue Cattle Supplement A (158). (3) A number of investigators have shown that under certain conditions, the addition of molasses to rations for ruminants results in a decrease in the *apparent* digestibility of the ration (223), especially of the protein (204, 214). Under other conditions such decreases have not been observed (228, 232). Whether or not a decrease in *true* digestibility occurs is open to some question (17).

**Molasses Grass and Legume Silages**—So much has been written on the value of molasses in the preservation of grass and legume silages and its use is so generally accepted that little space need be devoted here to this subject.

It might be well, however, to discuss briefly the conditions under which molasses should be used for the preparation of silage of the highest quality: (1) Moisture content of material to be ensiled. —Whether grasses or legumes, the moisture content of the material to be ensiled should be approximately 65% (249, 254, 257). (2) Minimum levels of molasses to be used.—The minimum levels of molasses which have been found to produce highest-quality silages are as follows: grasses or cereals, 40; mixed grasses and legumes, 60; alfalfa or clovers, 80; and soybean, 100 pounds per ton of silage (248, 255, 285, 306). (3) Type of silo.—Excellent results have been obtained in conventional silos, in pit silos (256), and in trench silos (253, 279) when the correct amount of molasses was used. However, for highest recovery of ensiled nutrients, a water-tight silo fitted with a moveable cap upon which pressure may be applied by covering with a layer of soil has proven very satisfactory in a number of instances (261). It

has been pointed out (262) that when wet grass was ensiled with molasses in a drained silo, nearly 20% of the added molasses was lost in the effluent. Consequently, in a water-tight silo the amount of molasses could be reduced by 20%. In the water-tight silo, the juices could be gathered and fed to cattle thereby reducing the loss of nutrients contained therein. **(4)** The use of lactic acid bacteria.—Ordinarily, the use of molasses alone as a preservative, when used at proper levels and under proper conditions, causes the development of a sufficiently great lactic acid fermentation to reduce the pH to the proper level for optimum preservation of the silage. It has been suggested, however, that under certain conditions it might be desirable to inoculate the molasses with a mixed culture of lactobacilli of the Streptobacterium plantarum type in order to be further assured of the development of a desirable microbial flora (234).

Advantages claimed (281) for the use of silage are as follows: **(1)** No waiting on weather; **(2)** no damaged hay; **(3)** no work in hot, dusty hay-mow; **(4)** saving in storage space; **(5)** big reduction in fire hazard; **(6)** less work at feeding time; **(7)** cleaner stables and cleaner milk; **(8)** eliminates feed wastage; **(9)** more growth and milk on less acreage; **(10)** most weed seeds destroyed completely by ensiling process (303, 318); and **(11)** flavor of milk and butter improved through destruction of off-flavors during the fermentation process (303).

A good silage preservative should: **(1)** prevent butyric acid production; **(2)** improve palatability; **(3)** keep nutrient losses at a minimum and **(4)** be economical to use. Of all preservatives, molasses appears to fulfill these requirements best (263).

## MOLASSES FOR HORSES AND MULES

The importance of molasses in the feeding of horses and mules is unquestioned. It is so well relished by these animals that caution should be exercised to make sure that excessive levels are not fed, which might produce poor results by causing an imbalance in intake of other essential nutrients.

The following notes should serve as a guide in the feeding of molasses to work stock: **(1)** Levels up to 9 pounds for mules and

13 to 15 pounds for horses per 1000 pounds of live weight, daily, have been found to produce satisfactory results under a wide variety of climatic and working conditions (325, 328, 333). (2) Molasses should be fed with some bran (333) and substituted for a part of the grain in the ration for work stock and, when properly supplemented with good quality hay, such as soybean, peavine or alfalfa, molasses appears to be equivalent to corn as a feed for these animals (328, 333). (3) Molasses increases the appetite of work stock for the other feeds in the ration. (4) Molasses feeding appears to reduce the number of cases of "dietetic ailments" such as colic, etc, and improves the general health of horses and mules (323). (5) Too heavy feeding of molasses during hot summer months may increase the sweating and "winding" of mules according to one group of investigators (331). However, another worker did not find this to be the case in horses receiving as much as 15 pounds of molasses per day under Australian weather conditions (333).

## MOLASSES IN THE FEEDING OF SWINE

The evidence on the feeding of molasses to swine is more conflicting than is that for the other species of farm animals. Of 54 reports on experimental work using molasses with swine, good results were obtained in 35 cases while 19 papers show poor results from molasses feeding. In some instances, the poor results can be attributed to the use of excessive levels of molasses (352, 364); in others, molasses was substituted for grains without adjusting the diet to make up for the reduced protein level (339, 357, 363, 366), while in others, multiple nutritional deficiencies appear to have been present in the basal ration used in the investigations (374, 376). Swine, being monogastric animals, do not contain the microbiological flora of the ruminant and, therefore, lack the ability to make use of non-protein-nitrogen compounds (such as those in beet molasses) in place of protein. Furthermore, because they lack a rumen, most of the B-vitamins for pigs must come from the diet. When the proper effort is not made to balance the diet in respect to protein and B-vitamins, poor results are likely to occur. In the experimental studies in which well-balanced swine rations were used, molasses was shown to give excellent results when substituted for corn, barley, or oats at proper levels (342, 347, 348, 357, 360, 364, 365).

The optimum levels of molasses in swine rations appear to be: (1) Ten per cent of the ration for weanling pigs; (2) Twenty per cent of the ration for pigs weighing from 80 to 100 pounds; (3) Twenty to forty per cent of the ration for pigs weighing 100 pounds or more (342, 360). When fed under these conditions, molasses has been shown to have a feeding value ranging from 75% to 111.6% that of the cereal grains (360). The average grain-replacement value of molasses for swine appears to be in the neighborhood of 85%. According to one investigator, mixtures of molasses with oats gave much better results than were obtained with mixtures of molasses and corn (382). This is possibly due to the beneficial effect of the slightly higher protein level in oats as compared to corn.

When proper attention was given to the nutritional balance of the ration, especially as regards the protein level, the use of molasses in swine feeds has been shown to produce not only better and more economical weight gains, but also improved quality of the pork (350) and caused superior plumpness, smoothness and general finish (355).

## MOLASSES FOR POULTRY

**Molasses in Mixed Poultry Mashes**—The investigations on the use of molasses in poultry rations furnish excellent evidence of the value of this material in the rations of all classes of poultry. Only when molasses was used at excessive levels in the diet were undesirable results obtained. A number of studies have been conducted in which molasses was substituted for corn in chick starting and growing rations. Under these conditions, levels of 4 to 5% molasses produced results which were at least equivalent to those obtained with similar rations without molasses (395, 401, 417, 422, 425, 426). Other studies showed that in rations for laying hens, cereal grains could be replaced by molasses up to a level of 7.5% of the total ration with no reduction, indeed in most cases with an accompanying increase, in egg production and a decrease in mortality (396, 416, 422, 425). For fattening poultry, levels of 10 and 15% (395, 422) molasses have been shown to produce more rapid gains than were obtained with similar rations without molasses. In one study, 15% molasses appeared to be excessive, thus indicating that the optimum level for this purpose is more nearly 10% (425). In

addition to producing increased gains, molasses has been reported to aid in the development of the deep yellow pigmentation of skin and flesh which is so desirable in finishing poultry as broilers and fryers (411).

In addition to its value as an execellent source of highly available energy for growth and egg production, molasses appears to be beneficial in the treatment of several poultry diseases (407, 410 418, 419). In this capacity, its "flushing effect" when fed at high levels, which is undesirable in ordinary poultry keeping, probably aids in the treatment of the disease by establishing conditions in the intestinal tract of the birds which are unfavorable for growth of the harmful microorganisms and by flushing these microorganisms and their toxins out of the intestinal tract.

**Molasses Grass and Legume Silages**—Investigations on the use of molasses grass and legume silages for poultry have shown that silages, produced in the same manner as those which are designed for ruminant feeding, have excellent feeding values for poultry (427, 431, 432). Since poultry cannot digest cellulose, only young grasses and legume plants should be used in preparing silage for poultry feeding. If this is done and if the silage is properly prepared, chickens and turkeys will consume the silage as readily as fresh-chopped grass and at a rate up to 4 pounds daily per 100 birds (431).

## COMPOSITION AND NUTRITIVE PROPERTIES OF MOLASSES

As our knowledge of the nutrient requirements of the various classes of farm animals has increased, the feeding of these animals has gradually changed from the earlier trial-and-error methods to the present-day scientific methods. Thus, in considering any particular ingredient for use in an animal feed, we no longer want to know how this ingredient has performed in feeding tests using a wide variety of diets. Today, we are able to analyze an ingredient for most of its nutrients and then calculate just how its nutrient composition can best be fully utilized in mixed ration. Each and every ingredient which makes up one of our present-day feed mixtures is known to contain sizeable amounts of certain of the required nutrients and to be a relatively poor source of certain of the other

nutrients. The successful feed manufacturer is one who has the knowledge and takes the care to fit each ingredient together with all of the other ingredients in such a way that the feed meets all of the nutritional requirements of the animal for which it is designed without undue wastage or excess of any nutrient. It is for this purpose that the accompanying Annotated Bibliography contains a section on the composition and nutritive properties of molasses.

The investigations presented in this section show that, although molasses is most valuable for its high content of readily available energy, it is also an excellent source of highly available essential minerals and of important vitamins. Cunningham (440) has presented an interesting report showing that sheep drenched with 680 grams of molasses exhibited a 50% increase in blood calcium and magnesium levels within one hour and that the effect persisted for over 5 hours. Drenching the sheep with soluble calcium and magnesium salts, supplying amounts of calcium and magnesium equivalent to those supplied by the molasses, was not as effective in raising the blood levels, nor so persistent. This author suggests that these findings indicate the possible beneficial use of molasses in the prevention and treatment of milk fever and grass staggers. Several investigators have demonstrated high biological value of iron present in molasses as evidenced by its effectiveness in curing the anemia which occurs in rats fed a milk diet (449, 472, 484). Molasses has been shown also to be an excellent source of pantothenic acid, pyridoxine, biotin, inositol and certain unknown growth factors. Early studies by Taylor and associates (491, 492) also indicated that molasses is a rich source of vitamin E. The finding by Gyorgy and Tomarelli (448) that molasses is a good source of antioxidants capable of retarding the coupled oxidation of butter yellow in mixtures with linoleic acid, may support the view that molasses contains vitamin E, or on the other hand, may indicate that Taylor, et al, obtained, from other antioxidants in molasses, a sparing effect upon the vitamin E requirement of their experimental animals.

It is evident from a careful inspection of the nutrient composition of molasses that it is a valuable ingredient for use, not only in rations for ruminants, but also in rations for the more fastidious farm animals, swine and poultry.

# ANNOTATED BIBLIOGRAPHY

## MOLASSES IN THE FEEDING OF RUMINANTS

### Beef Cattle

1. Archibald, E. S., **Beef Cattle.** *Canada Exp. Farms Rpt.* (1914).

In fattening steers, grain was profitably replaced by molasses in limited quantities. Molasses appeared to have a more beneficial effect when fed to good stocker than to good butcher cattle getting the same amount of grain. In dairy cattle, molasses feeding caused increased milk production at more reasonable costs than on the same rations without added molasses.

2. Archibald, E. S., **Beef Cattle.** *Canada Exp. Farms Rpt.* (1916).

Sixteen Shorthorn steers were divided into 4 groups of 4 each. All steers were fed a mixture of 40% barley and oats, 40% bran, 10% linseed meal and 10% cottonseed meal, with a roughage of turnips and clover hay, and lots (2) and (3) received 50% more roots and meal than lots (1) and (4). Half of each lot received, in addition to the regular ration, 2 lbs. of molasses per head per day. Average daily gain without molasses was 1.771 lbs.; with molasses 2.17 lbs.

3. Atkeson, F. W., Cave, H. W., and Riddell, N. H., **Preparation and palatability of molasses—corn fodder mixtures.** *Kansas Agr. Exp. Sta. Bien. Rpt.* **1935/36**:69-70. (1936).

Experiment was designed to determine effect of various levels of molasses on (1) dustiness of finely ground corn fodder and (2) the palatability to dairy cows. The levels of molasses used were 10, 20, 30, 40, 50, 60, and 70% of the ration.

(a) 10% molasses practically eliminated all dust, while 30% molasses eliminated fine particles and would probably keep the feed from "blowing" when fed.

(b) Finely ground material held 70% molasses while chopped material would hold only 60%.

(c) All mixtures above 30% molasses were sticky.

(d) A 30% molasses mixture appeared to be relished best by the cows but the 20% and 40% mixtures were also quite palatable.

(e) The 10% molasses mixture seemed unpalatable because it was dry and had little sweet taste.

4. Barnett, E., and Goodell, C. J., **Preliminary reports of experiments with feeding steers, using cottonseed meal and molasses.** *Mississippi Agr. Exp. Sta. Circ.* **48**:12. 1923; *Exp. Sta. Rec.* **49**:869-70. (1923).

In a 121-day feeding test, using 3 lots of 10 yearling steers a basal diet of corn silage ad libitum and some hay. Lot (1) also received 5.48 lbs. cottonseed meal; Lot (2) 5.48 lbs. cottonseed meal and 2.59 lbs. of molasses; Lot (3) 5.48 lbs. cottonseed meal and 5.21 lbs. molasses, per day. Average daily gains throughout the test were (1) 2.28, (2) 2.38, and (3) 2.51 lbs., per steer. Lot (3) showed the laxative effect of molasses, but finished better than the other two lots.

5. Barrentine, B., and Leveck, H., **Wood molasses for steer feed.** *Flour & Feed.* **50**, no.6:34. (1949).

The results of a 120-day feeding trial indicated that wood molasses could be substituted for one-fourth of the corn in steer rations with satisfactory results. In a reversal test, the steers receiving molasses gained more than those on the basal ration without molasses. Attempts to increase the level of wood molasses resulted in feed refusal by the steers, showing a lack of palatability at higher levels.

6. Bentley, O. G., Klosterman, E. W., and Moxon, A. L., **Supplements to poor quality hay for fattening cattle.** *J. Animal Sci.* **11**:757. (1952).

Gains were usually slower when part of the soybean meal in the ration was replaced by an equivalent amount of urea nitrogen. However, when fed with 1 lb. of molasses the gains of steers fed urea and three-fourths lb. of soybean meal per head daily were equal to those fed 1.5 lbs. of soybean meal. This was not true when the same rations were fed without molasses.

7. Blizzard, W. L., **Blackstrap molasses with corn and oats for fattening steer calves.** *Oklahoma Agr. Exp. Sta. Rpt.* 1936/38: 41-2. (1938).

Four lots of 8 Hereford steers each were fed: (1) Basal diet of corn, cottonseed cake and prairie hay; (2) Basal ration with half the corn replaced by molasses; (3) Basal ration with three-quarters of the corn replaced by molasses; (4) Basal ration with one-half of the corn replaced by molasses, the other half by oats. The average daily gains were: (1) 2.07, (2) 1.78, (3) 1.72, and (4) 2.00 lbs. per steer over a 162-day period.

8. Blizzard, W. L., and Taylor, B. R., **The ultilization of blackstrap molasses with corn and oats in fattening steer calves.** *Proc. Am. Soc. Animal Production.* 30:98. (1937).

For abstract see No. 7.

9. Bray, C. I., Snell, M. G., Morrison, F. L., Jackson, M. E., and Rhoad, A. L., **Feeding blackstrap molasses to fattening steers.** *Louisiana Agr. Exp. Sta. Bul.* 394:43. (1945); *Flour & Feed.* 40, no.3:32. (1948).

Following an excellent review of the literature relative to the feeding of molasses to livestock and of earlier results at the Louisiana station, 5 experiments are described in dealing with the use of molasses in fattening yearling steers on pasture and in drylots, conducted over a 10 year period. The usual basal ration consisted of rice polish, rice bran, cottonseed meal and rice straw. Molasses was substituted, at various levels up to 50% of the concentrate, for equal amounts of rice polish and rice bran. Corn was used in place of rice polish and rice bran as a positive control. Levels of molasses of 12.5%, 25%, 37.5%, and 50% of the concentrate all produced better gains than the basal diet. The 25% level produced the best gains, approaching those produced by the corn-cottonseed meal-rice straw positive control diet. The authors calculated that 100 lbs. of molasses showed a feed replacement value equivalent to 93.2 lbs. (Range 85-109.9 lbs.) of corn, when used with the rice products and cottonseed meal.

10. Burns, J. C., **Steer-feeding experiments.** *Texas Agr. Exp. Sta. Bul.* 110:3-23. (1908).

Molasses very profitably replaced nearly half the Indian corn in a mixed ration of molasses, Indian corn, cottonseed meal and hulls.

11. Burroughs, W., **New horizons in beef supplements.** *Feed Age.* **3,** no.4:20-4. (1953).

A discussion of the balance of nutrients required by rumen micro-organisms in order to obtain optimum utilization of low-grade roughages. These include: (1) Proteins or nitrogen such as that supplied by oil meals or urea; (2) Energy, a small part of which must be in the form of readily available carbohydrate such as the sugar in molasses; (3) Minerals, phosphorus and sulfur in particular; (4) Trace minerals, of which cobalt appears to be of particular importance; (5) Unidentified factors found in a number of protein-rich feeds and in high quality roughages and alfalfa meal. These are the bases for such developments as Purdue Supplement A and Iowa No. 1 and Iowa No. 2 supplements for beef cattle feeding with low-grade roughages such as corn-cobs and straw.

12. Calloway, R. C., **Feeding blackstrap molasses to young calves.** *Louisiana Agr. Exp. Sta. Bul.* **180**:22. (1921).

Fourteen newborn calves were divided into 2 groups. Both lots were fed for 24 weeks on skim milk, a grain mixture, hay, and corn and soybean silage. To the grain ration of half the calves was added blackstrap molasses, in small amounts at first, but at the rate of 2 lbs. per day as the calves grew older. The molasses did not produce scours when fed cautiously. It acted as an appetizer and increased gains somewhat.

13. Calloway, R. C., **Feeding experiments.** *Louisiana Agr. Exp. Sta. Rpt.* **1921**:26-7. (1921).

Blackstrap molasses fed with grain to young calves was found to be not only nutritious but a good appetizer, to have a tonic action, make the grain more palatable, and improve the quality of the skin and hair.

14. Connell, W. E., **Beet molasses for steers.** *Flour & Feed.* **52,** no.1:28. (1951). (Report of talk given at Feeders Day Meeting, Colorado A & M College).

Beet pulp with 4 types of beet molasses and molasses residues were tested with steers. Steers fed No. 1 Hipro molasses pulp (concentrated Steffens which contains less sugar but more nitrogen than Johnstown "B" molasses) and MC-47 molasses (concentrated filtrate from which glutamic acid has been largely removed and to which some inorganic matter has been added) made gains equivalent to those on Johnstown "B" molasses; 367 lbs. average for the 140-day test, but were appraised at a higher market price.

15. Conrad, H., **Studies and experiments with molasses as a feed, with special consideration of the effect of the strontium content of molasses.** *Inaug. Diss., Univ. Bern.* p. 36 (1909); *Exp. Sta. Rec.* **24**:672. (1911).

Calves were fed molasses in considerable quantities for 82 days with no harmful results. Molasses containing strontium when fed to cows and goats increased the per cent of fat but not the amount of milk. Although small quantities of strontium were recovered in this milk, the flavor or odor of the milk were not affected and the milk was not harmful when fed to nurslings.

16. Cowsert, W. C., **Blackstrap molasses about equals corn in livestock ration.** *Mississippi Farm Res.* **3**:8. (1940).

17. Craig, J. A., and Marshall, F. R., **Experiments in steer feeding. III. Molasses for steer feeding.** *Texas Agr. Exp. Sta. Bul.* **76**:17-8. (1904).

Using a basal diet of cottonseed meal and hulls 2 lots of steers were fed with and without molasses over a 100-day trial. The lot receiving the basal diet gained 2.59 lbs. per steer per day while that receiving this diet plus molasses gained 3.10 lbs. per steer per day. In addition to increasing the growth rate, the molasses appeared to cause a saving in the amount of feed required per pound of gain.

18. Craig, J. A., and Marshall, F. R., **Cattle feeding experiments.** *Texas Agr. Exp. Sta. Bul.* **86**:20. (1905).

In the first of the experiments reported on the value of molasses for fattening cattle 1 lot of 6 steers received 14 lbs. cottonseed meal and corn chop, 1:2, and 12. 5 lbs. of cottonseed hulls with a full feed-

ing of molasses (3.1 qts. per head) and made an average daily gain in a 70-day period of 1.71 lbs. at a cost of 10.05¢ per lb. Similar animals fed the same ration without molasses gained 1.27 lbs. per day at a cost of 11.3¢ per lb. Two subsequent experiments with steers yielded similar results. In one experiment with 10 pigs per lot, the lot receiving molasses made the best and most economical gains. Data on the economical use of molasses as a horse feed are also summarized.

19. Culbertson, C. C., Evvard, J. M., Hammond, W. E., and Bassett, C. F., **Cane molasses for finishing calves.** *Iowa Agr. Exp. Sta. Leaflet.* **27**:8. (1929).

Two experiments were conducted. In the first, a basal ration consisting of shelled corn, linseed meal, alfalfa hay and salt was fed to both lots of 5 calves for 150-days, whereupon 1 lb. of cane molasses was added to the diet of one lot for the next 120-days. The average daily gains were 2.38 lbs. for the lot receiving molasses and 2.42 lbs. for the lot without molasses. The second trial was similar to the first except that corn silage and cerain minerals were also fed. In this trial the average daily gains were 2.31 lbs. per head with molasses and 2.32 lbs. per head without molasses.

20. Dahlberg, H. W., **High-protein beet-molasses feed.** *Through the Leaves.* **1933**:136 (Sept. 1933); *Facts About Sugar (Sugar Abstracts)* **28**:435. (1933).

Beet molasses contains sufficient nitrogen so that in fattening steers no cottonseed-oil cake is needed if the molasses is fed liberally and plenty of hay is provided.

21. Dalrymple, W. H., **Cattle feeding on the plantation and farm.** *Louisiana Agr. Exp. Sta. Bul.* **151**:13. (1915).

The experience of one feeder is cited in which 49 lbs. of corn silage, 6 lbs. of blackstrap molasses and 5 lbs. of cottonseed meal per cow per day were fed for 111-days as satisfactorily as on more expensive rations.

22. Deenik, Z., **The value of cane tops, cane tops silage and molasses in beef production.** *Proc. S. African Sugar Technol. Assoc.* **14**:56-64. (1940); *Biol. Abst.* **17**:148. (1943).

Half of the grain in a ration of grain, cane tops and cane tops silage could be replaced successfully with molasses. Neither the quality of the beef nor the color of the fat was impaired.

23. Edwards, F. R., **Molasses as a substitute for corn in beef-finishing rations.** *Proc. Am. Soc. Animal Production.* 24:176-8. (1931).

Using a basal ration of corn, cottonseed meal and hulls and a mineral mixture, one lot received blackstrap molasses as a 25% replacement, another, as a 50% replacement of the corn. The use of the smaller amount of molasses gave results nearly as good as corn, but did not appear to cause any improvement over the basal diet.

24. Edwards, F. R., and Massey, A. A., **Beef cattle production in Georgia.** *Georgia Agr. Exp. Sta. Bul.* 184. (1934).

A basal ration was fed with (1) full corn; (2) ¾ corn and ¼ molasses; and (3) ½ corn and ½ molasses. Average daily gains per steer were: (1) 2.36, (2) 2.28, and (3) 1.99 lbs. over a 112-day experimental period. The steers receiving molasses were not considered to have as good finish as those on the "corn" ration.

25. Evvard, J. M., **Report of work at the Iowa Station in animal husbandry.** *Iowa Agr. Exp. Sta. Rpt.* (1920).

The results of feeding experiments indicated that, when fed with a standard corn belt ration, cane molasses is more valuable for cattle than beet molasses.

26. Evvard, J. M., and Culbertson, C. C., **Cane vs. beet molasses for fattening two year old steers, 120 days.** *Proc. Am. Soc. Animal Production* 1920:62. (1921).

Seven groups of steers, 7 per group, with 5 hogs following each group were fed: (1) shelled corn, linseed meal, corn silage, clover hay, and block salt (Basal diet); (2) basal diet plus one lb. of cane molasses; (3) basal diet plus 3 lbs. cane molasses; (4) basal diet plus 5 lbs. cane molasses; (5) basal diet plus 1 lb. beet molasses; (6) basal diet plus 3 lbs. beet molasses; (7) basal diet plus 5 lbs. beet molasses. The average daily gains of the steers were: (1) 3.033,

(2) 2.880, (3) 3.191, (4) 2.886, (5) 2.824, (6) 2.912, and (7) 3.084 lbs. per steer over the 121-day fattening period. The molasses had a beneficial effect on the hogs following the steers; cane more so than beet molasses.

27. GERLAUGH, P., **Molasses in the ration of fattening calves.** *Ohio Agr. Exp. Sta. Bul.* **463**:1-12. (1930).

A basal ration of 2 lbs. of a protein supplement, 6.5 lbs. corn silage, and 1.5 lbs. of mixed hay per head daily was fed to 5 lots of 20 calves each, averaging approximately 371 lbs. per head for 252 days. In addition the various lots received: (1) shelled corn ad lib.; (2) 2 lbs. of cane molasses replacing an equivalent weight of corn; (3) 2 lbs. of cane molasses plus ad lib. corn; (4) cane molasses ad lib. in addition to corn ad. lib.; and (5) 2 lbs. of beet molasses in addition to ad lib. corn. The average daily gains were: (1) 2 lbs., (2) 1.92 lbs., (3) 2.12 lbs., (4) 2.17 lbs., and (5) 2.14 lbs. The feeding of either cane or beet molasses increased feed consumption and thereby increased water consumption proportionately. The author believes that the results indicated the presence of a "growth factor" in both cane and beet molasses which may play an important role in long-time feeding program.

28. GERLAUGH, P., **Molasses in rations for fattening calves.** *Proc. Am. Soc. Animal Production* **24**:179-82. (1931).

Cane and beet molasses were fed with corn to calves during 2 years; one year for 36 weeks, the other for 40 weeks. Treatments: Basal—2 lbs. mixture of linseed and cottonseed meal, silage and hay; plus (1) full-fed corn; (2) 2 lbs. cane molasses substituted for corn; (3) 2 lbs. cane molasses in addition to whole ration; (4) ad lib. basal and molasses; (5) 2 lbs. beet molasses and full-fed basal. Results: (1) molasses increased feed consumption, (2) calves fed 2 lbs. molasses grew best and were less fat, (3) molasses appeared to contain an unknown growth factor. In second year, levels were reduced. Increased growth over basal diet was obtained with 1 lb. and 2 lb. but not with ½ lb. of molasses per day.

29. GERLAUGH, P., **Molasses for fattening steer calves.** *Ohio Agr. Exp. Sta. Bul.* **497**:122. (1932).

Five lots of 20 calves each were fed: (1) (Basal diet) 1 lb. each of linseed meal and cottonseed meal, 6.5 lbs. of silage, 1.5 lbs. of mixed hay and shelled corn ad lib.; (2) basal diet plus 2 lbs. of molasses; (3) basal diet plus 1 lb. of molasses; (4) basal diet plus 0.5 lb. molasses. "The calves fed one and 2 lbs. of molasses seemed to grow more than the calves in the lots fed one-half lb. or no molasses" over a 10-month experimental period.

30. GERLAUGH, P., **Molasses for fattening steer calves.** *Ohio Agr. Exp. Sta. Bimonthly Bul.* **154**:7-8. (1932).

A continuation of the study reported in Bul. 463 (1930). As in the previous study, levels of molasses up to 2 lbs. per head daily promoted just as good gains as that produced by the ration with corn ad libitum.

31. GERLAUGH, P., **Fattening steer calves.** *Ohio Agr. Exp. Sta. Quart. Bul.* **19**:3-5. (1934); *Bul.* 532. (1934).

A ration of 30% tankage, 20% cottonseed meal, 30% soybean meal, 15% linseed meal, 2% lime and 2% bone flour and 1% salt was more effective and economical than a mixture of 1:1 linseed and cottonseed meal, when fed with corn, silage and hay. A daily feeding of ½ lb. of molasses per head increased weight gains.

32. GERLAUGH, P., **Fattening steer calves—varying the amounts of supplement and molasses.** *Ohio Agr. Exp. Sta. Bimonthly Bul.* **198**:53-5. (1939).

For feeder calves, the addition of 1 lb. of molasses to 1.5 lbs. protein supplement was more economical and beneficial than the addition of 2.5 lbs. molasses or no molasses. While 2.5 lbs. protein supplement was improved by the addition of 1.5 lbs. molasses, this ration was poorer than the 1.5 lb. protein supplement plus 1 lb. molasses. The basal ration consisted of 7 lbs. silage daily plus shelled corn and hay to appetite. Pigs following the cows receiving molasses gave the best weight gains.

33. GRIMES, J. C., **Steer feeding experiment in Black Belt of Alabama.** *Alabama Agr. Exp. Sta. Bul.* **231**:3-8. (1930).

Results are given of three years work on the effect of adding molasses to a cottonseed meal—Johnson grass hay ration for fattening steers. In each experiment, the addition of molasses caused a significant improvement in the average daily gain in weight. The author calculated that 100 lbs. of molasses replaced 22.19 lbs. of cottonseed meal and 152 lbs. of Johnson grass hay in producing a 100 lb. gain, on the average, for the three experiments.

34. Grisdale, J. H., **Beef Production.** *Canada Exp. Farms Rpt.* p. 61-70. (1904).

The author states that commercial sugar beet pulp containing molasses has been found particularly valuable for young feeding stock and beef animals on account of its palatability and because it stimulates appetite.

35. Groenewald, J. W., and Van der Merwe, P. K., **The value of molasses in stock farming.** *Farming in South Africa.* 16:233-4, 251. (1941).

Small quantities of molasses can be added to low-grade roughage to make it more palatable to livestock. Attempts to supply molasses by adding it to the drinking water failed due to bacterial fermentation.

36. Gulley, F. A., and Carson, J. W., **Feeding experiment.** *Texas Agr. Exp. Sta. Bul.* 10:31. (1890).

As a part of a larger experiment, 3 pens of fattening cattle were given cottonseed hulls and meal moistened with molasses at the rate of one-half pint of molasses per head per day as an aid in making this feed more palatable. Another pen received silage moistened with molasses. It was concluded that "cheap molasses may be profitably added to cotton hulls and cottonseed meal but not to silage, which is already sweet or has an acid flavor which makes it palatable to the animal".

37. Hazen, M. W., and Comfort, J. E., **Comparison of corn and corn-molasses mixture for fattening beef calves before and after weaning.** *U. S. D. A. Tech. Bul.* 862:11. (1943).

In both the suckling and post-weaning stages, the calves on corn, cottonseed meal and alfalfa hay gained weight more rapidly, were

in better condition and required less concentrates per 100 lb. of gain than those receiving the same ration and molasses.

38. Heineman, W. W., et al, **Feeding value of wood molasses and dehydrated alfalfa when fed to fattening steers.** *Washington Agr. Exp. Sta. Circ.* **117**:1-2. (1950).

39. Henke, L. A., Work, S. H., and Burt, A. W., **Beef-cattle feeding experiments.** *Hawaiian Agr. Exp. Sta. Ann. Rpt.* **1938**: 68-70. (1938).

An experiment to determine value of molasses as a supplementary feed for steers on various kinds of pasture. Growth and carcass quality were improved considerably by feeding molasses, both on pigeon pea pastures and on grass pastures.

40. Henke, L. A., Work, S. H., and Burt, A. W., **Beef-cattle feeding trials in Hawaii.** *Hawaiian Agr. Exp. Sta. Bul.* **85**:37. (1940); *Hawaiian Agr. Exp. Sta. Ann. Rpt.* **1940**:18. (1940).

Aberdeen Angus steers on pastures of koa haole were divided and some were given supplementary feeding of cane molasses (ad libitum). The first trial with 30 steers on 60 acres lasted 246 days; the second with 24 steers on the same area, for 444 days; and the third, with 30 steers for 368 days. Average daily gains for the steers without molasses, in order of the trials were: 1.15 lbs, 0.84 lb. and 0.44 lb. or a combined average of 0.81 lb. Similar figures for the steers receiving supplementary molasses were: 1.5 lbs., 1.05 lbs., and 0.75 lb., or a combined average of 1.11 lbs., which represented a 37% increase in daily gains by the feeding of molasses.

41. Hills, J. L., **Feeding trials with cows.** *Vermont Agr. Exp. Sta. Rpt.* **1904**:462-511, 547-84. (1904).

Dried molasses—beet pulp was compared with wheat bran and with corn silage and was found, pound for pound of dry matter, to be of equivalent feeding value for cows.

42. Houston, J. W., and Riggs, J. K., **Citrus molasses in rations for fattening beef calves.** *Texas Agr. Exp. Sta. Prog. Rpt.* **1213 Cattle Ser.** 84. (1950).

Based on the results of 2 feeding trials, citrus molasses has a relatively greater feeding value at 4 lbs. per head than when fed at levels of 2 and 3 lbs. The average gains made by cattle on 4 lbs. of molasses and those on milo were about equal while those receiving 2 and 3 lbs. of molasses gained about 0.2 lbs. less per head per day. The productive energy of 100 lbs. of citrus molasses was found to be 55.71 therms.

**43.** Jacob, M., **Beef-cattle feeding experiments.** *Tennessee Agr. Exp. Sta. Rpt.* **45**: 20-1. (1932); *Rpt.* **46**:29-30. (1933).

Information obtained in tests comparing the feeding value of molasses with that of shelled corn for fattening beef cattle. A lot of steers receiving cottonseed meal, silage and molasses made better gains than the control lot receiving this ration without molasses.

**44.** Jacob M., and Duncan, H. R., **Winter-finishing two-year-old grass steers.** *Tennessee Agr. Exp. Sta. Bul.* **156**:12. (1935).

The addition of corn or molasses in a check ration of silage and cottonseed meal failed to improve results in most instances. However, slight advantages due to their addition were noted in respect to grades and carcass quality.

**45.** Jones, J. H., Hall, R. A., Neal, E. M., and Jones, J. H., **Blackstrap molasses in a beef cattle fattening ration.** *Texas Agr. Exp. Sta. Rpt.* **1941**:100. (1941).

Three lbs. of blackstrap molasses as replacement for a similar quantity of ground threshed Hegari produced an average daily gain of 2.04 lbs. per steer as compared to a gain of 2.12 lbs. per day per steer for those receiving the basal ration.

**46.** Kidder, R. W., **Fattening steers on winter pasture, with ground snapped corn, ground shallu heads, molasses and cottonseed meal.** *Florida Agr. Exp. Sta. Bul.* 391. (1943).

Three experiments were conducted, in each of which 3 lots of 10 steers were used. Lot (1) received cottonseed meal, ground snapped corn and molasses; Lot (2) cottonseed meal, ground shallu heads and molasses; and Lot (3) cottonseed meal (only). All steers were

on pasture and a "salt sick" mineral supplement was available to the steers at all times. The average daily gains for the 3 trials were: (1) 1.49, (2) 1.55, and (3) 0.85 lbs. per steer, a 120-day experimental period being used in each trial.

47. KIDDER, R. W., **Shallu, blackstrap molasses and sweet potatoes for fattening steers.** *Florida Agr. Exp. Sta. Ann. Rpt.* **1943**:145-6. (1943).

In addition to 2 lbs. of cottonseed meal per steer, 4 lots of 10 steers each were fed: (1) Equal parts of ground shallu and blackstrap molasses; (2) one part shallu to 3 parts molasses; (3) molasses ad libitum, and (4) equal parts of dried sweet potatoes and molasses. The steers in Lot (4) made the greatest gains and produced the highest grade carcasses.

48. KIDDER, R. W., **Shallu, blackstrap molasses and sweet potatoes for fattening steers on winter pasture.** *Florida Agr. Exp. Sta. Ann. Rpt.* **1944**:140-1. (1944).

Using the same experimental plan described earlier (1943), except for substitution of corn for shallu, the following conclusions were drawn: Lots (1), (2), and (4) were approximately equal and were superior to molasses as the only carbohydrate concentrate.

49. KING, F. G., **Cane molasses for beef cattle.** *Purdue Univ. Agr. Exp. Sta. Rpt.* (1937).

Molasses was fed under 4 different conditions, (a) with cottonseed meal, silage and wheat straw; (b) as a partial substitute for corn with full-fed cattle; (c) self-fed to full-fed cattle; and (d) mixed with ground oats to form the non-nitrogenous concentrate of the diet of full-fed cattle. The cane molasses was of slightly less value than equal weights of shelled corn. Under no condition did the molasses prove to be unsatisfactory or to have an undesirable effect on the cattle.

50. KIRK, W. G., SHEALY, A. L., and CROWN, R. M., **The use of molasses for fattening steers.** *Florida Agr. Exp. Sta. Ann. Rpt.* **1939**:80. (1939).

Three lots of 12 steers were fed equal amounts of sugar cane silage. In addition, Lot (1) received corn and cottonseed meal while Lots (2) and (3) received the same in which a part of the corn had been replaced by molasses. Average daily gains per steer were (1) 1.75, (2) 1.66 and (3) 1.62 lbs. over a 120-day period.

51. KIRK, W. G., SHEALY, A. L., and SMITH, D. J., **The use of molasses for fattening steers.** *Florida Agr. Exp. Sta. Ann. Rpt.* **1941**:66-7. (1941).

Three lots of 25 steers were fed a basal diet of alyce clover hay (limited), sorghum silage, corn and peanut meal. In addition, Lot (2) received blackstrap molasses as replacement for one-half the corn. Lot (3) received molasses ad libitum. Average daily gains per steer were (1) 2.08, (2) 2.04, and (3) 2.13 lbs. over a 120-day fattening period.

52. KIRK, W. G., SHEALY, A. L., and SMITH, D. J., **The use of molasses for fattening steers.** *Florida Agr. Exp. Sta. Ann. Rpt.* **1942**:67-8. (1942).

The experimental plan was the same as that described in the previous report by these authors (1941). Average daily gains per steer were: Lot (1) 1.82, Lot (2) 2.07, and Lot (3) 1.88 lbs. over the 120-day feeding period. Average final grades and dressing percentages were equivalent for all lots.

53. LAMB, A. R., **Utilization of molasses. The use of cane by-products in fattening beef cattle.** *Hawaiian Planter's Rec.* **40**:121-5. (1936).

An article pointing out the advantages of using molasses in beef cattle feeding in the Hawaiian Islands.

54. LAMB, A. R., **Utilization of molasses. II. Pen-fattening of beef cattle on molasses and other by-product feeds.** *Hawaiian Planter's Rec.* **42**:77-88. (1938).

Three lots of high grade feeder steers were compared. Lot (1) was on good pasture without supplementation. Lots (2) and (3) were reared in dry lot, receiving concentrate mixtures of screened

bagasse, pineapple bran, soybean meal, bonemeal and salt containing 38% molasses. The gains of the steers on dry lot were only slightly less than those on pasture over a 96-day fattening period. The steers finished in dry lot showed more finish, commanded higher market prices, and had a higher dressing percentage.

55. LANTOW, J. L., **Steer fattening rations built largely around corn fodder and silage with cottonseed meal and molasses as the added concentrates.** *New Mexico Agr. Exp. Sta. Bul.* 211. (1933).

The following rations were fed to yearling steers: (1) cottonseed meal 3.5, cane molasses 3, ground corn fodder 10.5 lbs.; (2) cottonseed meal 3, cane molasses 3, ground corn fodder 7 plus 4 lbs. alfalfa hay per head per day; (3) cottonseed meal 4.5, corn silage 25 with 4 lbs. alfalfa hay. Average gains were 2.3, 2.3, and 2.5 lbs. per head per day, respectively.

56. LIEBSCHER, W., **Feeding experiments with fat cattle given various mixed feeds containing molasses.** *Landeskultur.* 3:239. (1936).

In an experiment lasting 176 days, 5 groups of 6 cattle each received: (1) "green" molasses, (2) cellulose with molasses, (3) dried beet slices mixed with molasses, (4) "molasin" and (5) straw with molasses. Each ration had the same starch value and contained the same amount of digestible protein. In all groups the gains in weight were approximately equivalent and the various rations were considered to be about equally good. The digestibility of the organic matter of cellulose with molasses for 2 wethers was 92.4%. Although as much as 3.6 Kg. of molasses per 1000 Kg. live weight were fed, the quality of the meat was not affected.

57. LING, A. W., **The spraying of rough herbage with molasses.** *Univ. Bristol Dept. Agric. Hortic. Bul.* 22:12. (Oct. 1939).

In the early spring of 1939, experiments with cattle were carried on at 5 centers in Bristol Province in which rough and mostly unpalatable herbage was sprayed with molasses at the rate of 150 lbs. per acre. Excellent grazing resulted at 3 centers but the other 2 were not so favorable.

58. McCall, R., and Graham, W. R., Jr., **The value of several ammoniated products as feeds for beef cattle.** *J. Animal Sci.* **11**:770. (1952).

In experiments involving 251 steers, ammoniated citrus pulp, molasses and a saccharified by-product from furfural production (Furafeed) were compared with urea as protein substitutes. All of the ammoniated products compared favorably with urea as nitrogen sources when used to furnish one/fifth to two-fifths of the total nitrogen intake. A combination of Furafeed and ammoniated molasses, each supplying one-fifth of the nitrogen in the protein supplement, produced 0.08 lb. more gain per day than the controls, with almost identical feed efficiency.

59. McCampbell, C. W., and Winchester, H. B., **Cattle feeding investigations, 1919-1920.** *Kansas Agr. Exp. Sta. Circ.* **86.** (1921).

Three lots of 4 year old steers, 10 per lot, were fed: (1) (Basal diet) cane silage, 2.5 lbs. linseed oil meal, alfalfa hay and corn, (2) Basal diet with blackstrap molasses substituted for corn during last 45 days of test, (3) Basal diet without corn. The average daily gains were: (1) 1.29, (2) 1.08, and (3) 1.11 lbs. per steer over a 130-day period.

60. McComas, E. W., Douglas, J. R., and Southwell, B. L., **Corn-molasses mixtures compared with corn for fattening beef cattle in the coastal plain area.** *U. S. D. A. Tech. Bul.* **864**:1-10. (1943).

Four experiments were conducted to compare corn and molasses mixtures with corn alone when fed with velvet beans and peanut straw to Hereford steers. (1) Corn and molasses 1:1; (2) 3:1; (3) corn alone. Group (2), receiving 3 parts corn to 1 of molasses gained more, had a higher dressing percentage, higher grade carcass than group (1), one part molasses to 1 part corn. However, only in 1 experiment did group (2) excel group (3) (all corn). The 1:1 mixture was about 80% as efficient as corn; the 3:1 mixture about 90%.

61. McCraine, C. E., Bray, C. I., Singletary, C. B., Crown,

R. M., and FRANCIONI, J. B., JR., **Fattening steers with molasses fed in various ways.** *Louisiana Agr. Exp. Sta. Ann. Rpt.* **1948/49**:34. (1949).

Five lots of 8 calves each were fed: (1) corn, 79%; cottonseed meal, 21%; (2) corn, 46%; cottonseed meal, 23%; molasses-bagasse mixture, 31%; (3) corn, 46%; cottonseed meal, 23%; molasses-cottonseed hulls mixture, 31%; (4) corn, 46%; cottonseed meal, 23% and blackstrap molasses 31%; (5) corn, 28.6%; cottonseed meal, 28.6%; blackstrap molasses (free-choice) 42.8%. The average daily gains per steer for the 112-day feeding period were: (1) 1.848, (2) 1.455, (3) 1.366, (4) 1.991, and (5) 2.017 lbs.

**62.** MACAHILIG, R. G., **Rice straw and molasses as supplements to pasture feeds for range cattle.** *Philippine Agr.* **28**:561-75. (1939).

Two groups of 6 cows each were used. (1) Rice straw and molasses for about 1-2 hours daily, in addition to pasture feed. (2) Pasture feed only. Trials extended over 112 days during the dry season and 196 days during the wet season.

Dry season: Average gains: (1) 29.43 Kg. (2) 1.43 Kg.
Wet season: " " : (1) 19.93 Kg. (2) 16.45 Kg.

**63.** MARSHALL, F. R., and BURNS, J. C., **Kaffir corn and milo maize for fattening cattle.** *Texas Agr. Exp. Sta. Bul.* **97**:7-10. (1907).

Using a basal ration of cottonseed meal and hulls, experiments were undertaken with Shorthorn steers comparing the feeding values of molasses, Indian corn, Kaffir corn and milo maize. Levels of molasses up to 5 qts. per steer per day were used. It was concluded that one gallon of molasses per head, daily, is the maximum amount that can be fed without interfering with growth and causing very loose droppings.

**64.** MAYNARD, E. J., **Beet molasses in fattening rations.** *Breeders Gaz.* **79**:213. (1921); *Proc. Am. Soc. Animal Production* **1922**:73-4. (1922).

Three tests were conducted with fattening steers, averaging

780, 840 and 1050 lbs. weight respectively at the beginning of the tests. The average amounts of beet molasses fed were 2.3, 3.2 and 5.0 lbs. per head daily. In the first test the average daily gains were 1.82 lbs. without molasses and 1.93 lbs. with molasses; in the second test, 1.73 lbs. without molasses and 1.85 lbs. with molasses; in the third test, 2.63 lbs. without molasses and 3.05 lbs. with molasses. It was concluded that 100 lbs. of molasses fed to steers saved 79.1 lbs. of barley, 77.6 lbs. of corn silage, or 33.3 lbs. of alfalfa hay. For lambs, 1.5 lbs. per head per day appeared to be about the optimum amount. The molasses should be poured into the feeding trough first and the grain should be poured onto the molasses, so that the animals will obtain the molasses more slowly than they would if it were poured on top of the grain.

65. Mead, S. W., Regan, W. M., and Bartlett, J. W., **A study of the factors affecting the growth of dairy heifers.** *J. Dairy Sci.* 7:440-59. (1924).

Calves 6a and 7a were born only two days apart and as an effort to increase palatability of diet, 40% cane molasses was added to the alfalfa meal given calf 6a at 220 days of age. Calf 7a received the same diet without molasses. At 330 days, calf 6a gained 145.7 lbs.; calf 7a, 130.8 lbs. Calf 6a consumed 451 lbs. grain and 308.8 lbs. alfalfa. Calf 7a consumed 469 lbs. grain and 276 lbs. alfalfa.

66. Norton, C. L., and Eaton, H. D., **Dry calf starter for dairy calves.** *Cornell U. Agr. Exp. Sta. Bul.* 835:32. (1946).

Molasses, added at a level of 8%, improved the palatability of experimental calf starter feeds being fed with limited quantities of liquid milk.

67. Peters, W. H., **Feeding cane molasses to fattening cattle.** *Minnesota Agr. Exp. Sta. Bul.* 274:27. (1931).

Yearling steers were fed for 161 days in one test and steer calves for 189 days in another on good diets with and without supplemental cane molasses. Either small or large amounts of cane molasses caused a stimulating effect upon appetite in the fattening cattle, but did not produce an effect upon rate of gain under these conditions.

68. Peters, W. H., **Selection and purchase of feeders and rations for fattening cattle.** *Minnesota Agr. Exp. Sta. Bul.* 300. (1933).

Using 4 lots of 10 steers each, an experiment was conducted comparing ground and unground shelled corn, linseed meal and alfalfa hay and ground barley, linseed meal and alfalfa hay with and without added molasses. The average daily gains were best and amounts of feed required per pound of gain were least on the rations without molasses.

69. Riggs, J., Butler, O. D., and Gaines, J. A., **Molasses tests in Texas.** *Texas Agr. Exp. Sta. Prog. Rpt.* 1252. **Cattle Ser. 85.** (1950); *Flour & Feed.* **52,** no.2:28. (1951).

Corn and citrus molasses were compared with ground milo for fattening steers. The molasses was fed at a level of 4 lbs. per head per day. No significant differences in weight gains, feed consumption or carcass quality were obtained between the 3 lots.

70. Rusk, H. P., and Snapp, R. R., **Studies of feeding values of molasses for yearling steers.** *Illinois Agr. Exp. Sta. Rpt.* **1937/38**:79-86. (1938).

Four lots of 10 steers each were fed: (1) Protein supplement, corn silage, alfalfa hay, limestone and molasses (no grain); (2) same as (1) except one-half the molasses was replaced by 25% corn and 25% oats; (3) same as (1) except 50% molasses and 50% oats and no silage; (4) same as (1) with shelled corn (no molasses). Average daily gains were: (1) 2.08, (2) 2.51, (3) 2.17, and (4) 2.51 lbs. per steer over a 150-day period. Both the live cattle and the carcasses of the corn-fed lot graded highest; corn-oats-molasses next; and the all-molasses lot lowest.

71. Singh, L., and Singh, S. G., **Cane molasses as a cattle feed.** *Agr. and Live-stock in India.* **4**:156-75. (1934).

There is a prejudice against the use of molasses in cattle feeding in the Punjab. It is said to be injurious to health. Feeding experiments with bullocks and cows indicated that access to salt eliminated any trouble in this respect. Two lbs. of molasses could

replace 2 lbs. of maize and 0.9 lb. mixed roughage. An additional 2 lbs. of molasses was less efficiently used.

72. Singh, L., and Singh, S. G., **Further observations on cane molasses as a cattle feed.** *Agr. and Live-stock in India.* **5**:34-5. (1935).

Cane molasses was fed to bullocks at the rate of 2 lbs. per animal per day without ill effects during the winter months but caused ill health when fed in summer.

73. Singh, L., and Singh, S. G., **Factory cane-molasses as a cattle feed.** *Agr. and Live-stock in India.* **7**:347-58. (1937).

Two lbs. of cane molasses successfully replaced 2 lbs. of maize in a mixed ration for bullocks during the winter.

74. Singleton, H. P., and Ensminger, M. E., **The feeding value of dried molasses beet pulp and beet molasses for beef cattle.** *J. Animal Sci.* **3**:437. (1944).

An average daily allowance of 6.75 lbs. of beet molasses was consumed by yearling and 2-yr.-old feeder cattle in thin condition, grading "good" and "medium". This amount of molasses replaced a "considerable" amount of the grain ration. See abstract No. 75.

75. Singleton, H. P., Ensminger, M. E., and Heinemann, W. W., **Dried molasses-beet pulp and beet molasses for fattening cattle.** *State Coll. Washington Agr. Exp. Sta. Bul.* **469**:1-12. (1945).

In feeding trials with young steers it was found that levels up to 6.75 lbs. of beet molasses per head per day could be fed with favorable results. Under these conditions 100 lbs. of beet molasses appeared to have the feeding value of 75 lbs. of grain.

76. Skinner, J. H., and King, F. G., **Cane feeding molasses vs. mixed molasses feed as supplements to rations for fattening cattle.** *Purdue Univ. Agr. Exp. Sta. Bul.* **183**:882-91. (1915).

Three lots of steers were fed: (1) Shelled corn, cottonseed meal, clover hay and corn silage; (2) same as (1) plus cane mo-

lasses; (3) same as (1) (less cottonseed meal) plus cane molasses. The average daily gains were: (1) 2.27, (2) 2.61, and (3) 2.07 lbs. per steer over a 150-day fattening period. Thus, except where molasses was used to replace the protein concentrate, its addition resulted in a marked increase in rate of gain.

77. Skinner, J. H., and King, F. G., **Cattle feeding. 1936-1937. Cane molasses.** *Purdue Univ. Agr. Exp. Sta. Bul.* **430**:8. (1938).

Results indicated that molasses has a slightly lower feeding value than an equal weight of shelled corn. A mixture of ground oats and cane molasses produced gains as rapid and more economical than shelled corn but did not produce the same finish.

78. Snell, M. G., and Morrison, F. L., **Rice, rice by-products and molasses as feeds for fattening beef cattle and lambs.** *Louisiana Agr. Exp. Sta. Bien. Rpt.* **1939/40**:38-9 (1940).

In studies with cattle and lambs comparing the feeding value of molasses at various levels with that of corn, it was found that 12.5% molasses was 82% as good as corn for cattle and 107% as good as corn for lambs. However, as the level of molasses was gradually increased to 50% its feeding value fluctuated between 73 and 85% as good as corn for cattle and between 76 and 86% as good as corn for lambs. The averages for the relative feeding values of all levels of molasses as compared to corn was 80% for cattle and 86% for lambs.

79. Stubbs, W. C., and Barrow, D. N., **Cattle feeding with results of trials.** *Louisiana Agr. Exp. Sta. Bul.* **34**:1201. (1895).

In an experiment conducted to determine relative gains of "exposed" vs. "protected" cattle, the statement is made that "it was found advantageous to add molasses to a mixture of (cottonseed) meal and hulls to secure a better balanced ration. Four lbs. per day, however, seemed to be the maximum amount which could be fed with safety. Increasing this quantity invariably induced 'scours'. The molasses used was 'common black centrifugals' ".

80. Templeton, G. S., and Goodell, C. J., **Steer feeding results and actuary.** *Mississippi Agr. Exp. Sta. Bul.* 274. (1926).

Molasses was found to have a higher feeding value for cattle when fed at the rate of 2.57 lbs. per head, daily, than when fed at the rate of 5.15 lbs. per head per day.

81. Templeton, G. S., and Goodell, C. J., **Steer feeding experiments and actuary.** *Mississippi Agr. Exp. Sta. Bul.* 242. (1927).

Three lots of 10 yearling steers each were fed: (1) cottonseed meal, silage and Johnson grass hay; (2) same as (1) plus 2.5 to 3 lbs. molasses per head daily; (3) same as (1) plus 5 to 6 lbs. molasses per head daily. The experiment was repeated four times over a period of four years, the average experimental period being 114 days. Average daily gains for the four experiments were: (1) 2.28, (2) 2.43, and (3) 2.49 lbs. per steer.

82. Tomhave, W. H., and Bentley, F. L., **Steer feeding experiments.** *Pennsylvania Agr. Exp. Sta. Bul.* 183. (1903).

Using 10 steers per lot, one lot (1) was fed corn silage, corn stover, shelled corn and cottonseed meal, while another (2) received this ration with the substitution of molasses for 25% of the corn. The average daily gains were: (1) 2.43 lbs. and (2) 2.59 lbs. per steer over a 150-day period.

83. Trowbridge, E. A., **The use of a limited amount of molasses in fattening yearling steers.** *Missouri Agr. Exp. Sta. Bul.* 223:1-16. (1924).

Five lots of 8 steers each were full fed a basal ration of shelled corn and alfalfa hay plus various other materials. Lot (1) received linseed meal and corn silage; Lot (2) same as (1) plus 1 lb. cane molasses per head per day; Lot (3) corn silage and 1 lb. of molasses; Lot (4) linseed meal and molasses; Lot (5) molasses. The linseed meal was fed in the ratio of 1 lb. to 6 lbs. of corn. Hogs followed the steers in all lots. Average daily gains per steer were: Lot (1), 2.96; Lot (2), 3.00; Lot (3), 2.73; Lot (4), 3.04; and Lot (5), 2.97 lbs. The average pork produced per steer was: Lot (1), 33.75; Lot (2), 28.12; Lot (3), 24.37; Lot (4), 43.00; Lot (5), 21.50 lbs.

84. Trowbridge, E. A., Comfort, J. E., and Hazen, M. W.,

**Cane molasses as a substitute for corn in rations for calves.** *Missouri Agr. Exp. Sta. Bul.* 387:20-1 (1937); also *Bul.* 413:19-20. (1940).

Calves receiving a ration in which one-half the corn was replaced by molasses did not make as satisfactory gains as those receiving the control ration.

85. Trowbridge, E. A., and Moffett, H. C., **Molasses-alfalfa supplement for fattening yearling cattle.** *Proc. Am. Soc. Animal Production.* 1931:182-3. (1931).

A molasses-alfalfa mixture promoted approximately the same growth in yearling cattle as cottonseed cake when compared as supplements to shelled corn.

86. Trowbridge, E. A., and Moffett, H. C., **Blackstrap molasses in rations for fattening yearling steers.** *Missouri Agr. Exp. Sta. Bul.* 413:17-9. (1940).

A ration of molasses and cottonseed meal (7:1) was 92% as efficient as a corn-cottonseed meal (8:1) ration for fattening steers.

87. Webb, R. J., and Bull, S., **Effect of molasses and molasses feed on quality of beef.** *Illinois Agr. Exp. Sta. Bul.* 510:487. (1945).

Three groups of Hereford steers were fed for 150 days on (1) blackstrap molasses, soybean oil meal, corn silage and alfalfa hay; (2) corn, oats, soybean oil meal, alfalfa hay, corn silage and molasses; and (3) corn, soybean oil meal, corn silage and alfalfa. Group (1) gained 2.1 lbs.: (2) 2.5 lbs.; and (3) 2.5 lbs. per animal per day. The animals in group (1) required 31% more concentrates, 28% more silage, and 20% more hay per 100 lbs. gain than those in group (3). The feeding of molasses also appeared to be the cause of reduced market grade, increased shrinkage, and decreased dressing percentage. Lot (2) grew at the same rate as Lot (3) but required an increased amount of hay per 100 lbs. gain and carcass quality was inferior in the animals in Lot (2).

88. Weber, A. D., and Connell, W. E., **The value of molas-**

**ses as an appetizer (for beef cattle) when fed with cottonseed hulls (and) . . . with wheat straw.** *Kansas Agr. Exp. Sta. Bien. Rpt.* **1935/36**:62-3. (1936).

No evidence was obtained that sprinkling molasses over cottonseed hulls or good quality wheat straw would increase the amounts of these materials consumed.

89. Weiser, S., and Zaitschek, A., **Feeding experiments with molasses.** *Landw. Jahrb.* **37**, no.1:130-49. (1908).

In experiments with steers, the authors conclude that satisfactory results were obtained when 7.64 to 8 Kg. of molasses per 1000 Kg. live weight was fed as an addition to a basal ration of 4 Kg. alfalfa hay, 2 Kg. meadow hay, 3 Kg. wheat chaff, and 5 Kg. of clover or alfalfa seed screenings. Molasses was also very useful for horses, maintaining them in good condition when used at about 25% of the daily ration.

90. Woodman, H. E., Mansfield, W. S., and Garner, F. H., **The relative values of oats, beet-molasses pulp and dried sugar-beet pulp for the fattening of store cattle.** *J. Ministry of Agr. (Engl.)* **38**:985-93. (1931/32).

A trial with 20 cattle showed that for fattening, sugar beet-pulp and beet-molasses pulp were of equal value.

91. Woodward, T. E., and Lee, J. G., Jr., **Feeding blackstrap molasses to young calves.** *Louisiana Agr. Exp. Sta. Bul.* **104**:3-38. (1908).

In a test with 13 calves receiving skim milk, 4 to 8 lbs. twice daily, depending on age, plus oat, hay, crab grass hay and a grain mixture consisting of bran, corn meal and linseed oil meal, 2:2:1, some of the calves were also given varying amounts of molasses. Scouring occurred whenever the molasses level became a significant part of the ration.

**Dairy Cattle**

92. Anonymous, **Feeding for milk.** *Queensland Agr. J.* **7**:25-6. (1900); *Exp. Sta. Rec.* **12**:288. (1900-01).

During 2 periods of 15 days each, 6 cows were fed a ration of 20 lbs. corn fodder and, during the second period, were given in addition, 1.5 lbs. of molasses. The use of molasses resulted in a slight increase in the yield of milk and butter.

93. Anonymous. **Feeding experiments with molasses for milch cows.** *Tidskr. Landtman.* 16:497-502. (1895); *Exp. Sta. Rec.* 7:520-1. (1895-96).

Experiments were conducted at Alnarp Agr. College, Sweden, using 3 lots of East Friesian cows, 4 per lot. The basal ration (Lot (1) contained: 20 Kg. fodder beets, 5 Kg. hay, 2 Kg. ground feed, 1 Kg. wheat bran, ½ Kg. each of sunflower seed cake and peanut cake and ¼ Kg. each of rape-seed cake and palm-nut cake. Lot (2) received 1 Kg. molasses in addition to the basal and Lot (3) received ¼ Kg. molasses in place of 1 Kg. of ground oats and barley. These diets were fed as such for about 3 weeks, whereupon the molasses levels were increased by 1 Kg. for the subsequent 2 weeks. At the end of this time, all cows were given the basal diet without molasses for approximately 3 weeks. By the end of the experiment, milk production by Lot (1) had dropped 7.5% due to the advance in lactation period. Lot (2) dropped 7.7% while Lot (3) decreased only 3.4% in milk output. All cows gained weight during the experience.

94. Blakely, A. A., and Dewes, D. F., **Molasses will reduce after-calving complaints.** *New Zealand J. Agr.* 64:161-4. (1942).

Based upon wide experience in its use, the authors recommend molasses in order to prevent after-calving ailments.

95. Blosser, T. H., Scott, G. W., Jr., Erb, R. E., and Shaw, A. O., **The value of wood molasses as a feed for dairy cattle.** *J. Animal Sci.* 10:163-70. (1951); *J. Dairy Sci.* 32:719. (1949).

Eight Holstein and 2 Jersey heifers were divided into 2 groups and fed at a level 5% below Morrison's minimum standards for growing dairy cattle. One group received 2 lbs. wood molasses daily during the first 8 weeks and 4 lbs. per day during the last 7 weeks. Calves receiving molasses gained significantly more weight than the no-molasses group.

96. Bohstedt, G., Rupel, I. W., and Roche, B. H., **The feeding value of cane molasses when incorporated in grain mixtures for dairy cows.** *Proc. Am. Soc. Animal Production.* 1933:52. (1933). *Abst. Papers Ann. Meet. Am. Dairy Sci. Assoc.* 29:40. (1934).

It was estimated that cane molasses is worth about 75% as much as corn in rations for dairy cows.

97. Breirem, K., **Acetonemia in milk cows caused by war feed.** *Tids. Norske. Landbruk.* 50:11-24. (1943).

Tests made on 11,500 cows in Norway showed an increasing incidence of acetonemia. When possible, the feeding of mill wastes, molasses and oil cake to the cellulose-rich war diet was suggested.

98. Brenes, L. R., et al, **Use of cane molasses as part of the concentrate dairy ration using Merker grass as roughage.** *J. Agr. Univ. Puerto Rico.* 31:203-14 (1947).

99. Brintnall, E., **Blackstrap molasses for dairy cattle.** *Mississippi Agr. Exp. Sta. Circ.* 38:4. (1921).

Two lots of 2 cows each were fed a basal ration in which a part of the corn for one lot was replaced by molasses. The conclusions drawn from the experiment were that, pound for pound, corn and molasses are practically equal in feeding value for milk production. Fifteen calves from 3 to 6 months of age, fed rations of equal parts of corn and oats and equal parts of molasses and oats, with and without skim milk, indicated that molasses is at least equal to corn as a feed for dairy calves.

100. Brouwer, E., **Supplementary feeding of milk cows on pasture and the quality of butter produced.** *Ver. Exploit. Proefzuivelboerd. Hoorn, Ann. Rpt.* 1931:113-56. (1931); *C. A.* 27:4596. (1933).

Results of 4 experiments with 7 observational periods using 62 cows to determine if the consistency of spring and autumn butter, often too soft, could be altered by supplements to the diet. Mixtures of oat straw and molassine pulp had little effect on the consistency of the butter.

101. Butler, T., **Blackstrap molasses and lespedeza hay for cattle.** *Prog. F.* 31:3. (1916).

102. Crampton, E. W., **Soaked beet pulp vs. malt sprout-barley screening-molasses mixture as a succulent feed for cows in milk.** *Sci. Agr.* 12:174-7. (1931).

A soaked malt sprouts-barley screenings-molasses combination was as good nutritionally as soaked beet pulp, but appeared to be less palatable; mixing some beet pulp with this combination proved satisfactory in all respects.

103. Cunningham, W. S., **Feeding dairy cattle in Arizona.** *Arizona Agr. Exp. Sta. Bul.* 127:275-98. (1928).

Alfalfa alone in addition to silage and a grain mixture produced about 3% less milk than an alfalfa-blackstrap molasses mixture (containing 15% molasses) fed in the same manner.

104. Davies, W. L., **The fishy flavor of milk caused by feeding beet by-products.** *Agr. Progress* 13:112-5. (1936).

Beet molasses contains approximately 5.4% betaine. It also contains traces of trimethylamine and trimethylamine oxide. Trimethylamine and its oxide, when fed to cattle promptly appear in the urine in complete recovery. However, according to the author much of the betaine and chlorine are retained in the body and may break down slowly yielding trimethylamine oxide which may enter the milk. The small amount of this compound which enters the milk appears to combine with the unsaturated fatty acids of the butterfat. This union is believed to be responsible for the fishy taste of milk. The taint is concentrated in the cream and butter.

105. Ehrenberg, P., and Scholtz, A., **Replacement of food protein by ammonium bicarbonate in the feeding of milk cows.** *Biochem. Z.* 270:188-202. (1934); *C. A.* 28:5108. (1934).

By feeding milk cows 1 Kg. of oil cake, 0.8 Kg. ammonium bicarbonate and replacing the lost starch value by 13 Kg. of silage and 1 Kg. green molasses, a daily production of about 14.5 liters of milk (3.2% fat) was maintained.

106. Ellison, W. M., and Catala, J. V., **Corn chops vs. cane molasses for milk production in Puerto Rico.** *Puerto Rico Dept. Agr. and Labor Sta. Ann. Rpt.* **1928**:99-100. *Eng. ed.* (1928).

Two groups of 6 cows received a basal ration of wheat bran, alfalfa meal, cottonseed meal, linseed oil meal, steamed bone meal, and salt. In addition, Lot (1) received cane molasses and Lot (2) corn chops. Both lots also received poor quality forage of sugar cane tops mixed with some grasses. Lot (2) consumed 30 lbs. more feed and produced 201.6 lbs. more milk than Lot (1) in a 30 day period; nevertheless a greater profit was made on Lot (1).

107. Freer, G. H., and Hayden, C. E., **Acetonemia in a dairy cow accompanied by blindness.** *Cornell Vet.* **30**:116-7. (1940).

Blindness, which accompanied acteonemia in a single dairy cow, was found to disappear when molasses was added to the ration as a treatment for the acetonemia.

108. Friis, F., **Eighth and ninth years' feeding experiments with dairy cows.** *Ber. K. Vet. Landbohojskoler Lab. Landokon. Forsog (Copenhagen).* **1897.** p. 107.

Further studies comparing molasses feed (palm-nut meal, wheat bran and molasses, 1:3:4) with barley and oats. The results indicated that molasses feed and mixed grain (barley and oats) possess the same feeding value, pound for pound, for dairy cows when fed in similar food combinations with oil cakes, roots, hay and straw.

109. Frolich, G., and Haring, F., **Investigation of the protein-sparing effect of molasses in dairy cows.** *Kuhn-Archiv.* **40**: 49-77. (1936).

Twenty-one milk cows were fed in a series of 4 trials. The control lots received oilmeal as the concentrate while the experimental lots received 20% molasses and 80% oilmeal. Under these conditions, the molasses plus oilmeal gave results approximately equivalent to oilmeal alone, thus exhibiting a sparing effect on the amount of protein supplement required.

110. Grisdale, J. H., Archibald, E. S., and Gussow, H. T., **Dairy cattle.** *Canada Exp. Farms Rpt.* **1913.**

In dairy cattle it was found that 10 parts of molasses could satisfactorily replace 10 parts out of 100 of the concentrate mixture being used, which consisted of bran, gluten meal, cottonseed meal, and dried brewers' grains, (6:3:2:2). When molasses replaced the mixture to the extent of 20%, milk production was decreased, cost of production was increased and the cows developed scours and lost weight.

111. Henke, L. A., **Cane molasses as a feed for dairy cows.** *Hawaiian Agr. Exp. Sta. Bul.* 73:17. (1934).

Two experiments are reported. Results show that, when properly supplemented with high protein feeds, cane molasses may safely be substituted for 25% of the other concentrates fed to dairy cows. There was no indication of decreased reproductive efficiency or increased abortion. Figures on the economy of feeding molasses as applied to Hawaii are given.

**112.** Henke, L. A., and Goo, G. W. H., **Molasses poured over roughage increases milk production.** *Hawaiian Agr. Exp. Sta. Rpt.* **1936:** 69. (1936).

In one 12-week experiment with 6 cows, the addition of 4 lbs. of cane molasses poured over the roughage, increased milk production by an average of approximately 2 lbs. per cow per day. In a second similar test an increase of 1 lb. of milk per day was noted. The cows receiving molasses also gained weight.

**113.** Henke, L. A., and Goo, G. W. H., **Rations using maximum amounts of pineapple bran and cane molasses for dairy cows.** *Hawaiian Stat., Anim. Husb. Div. Prog. Notes.* **No.13:**6. (1936).

Using 6 cows and the double-reversal system of feeding, a ration of pineapple bran and molasses with soybean meal as protein supplement was compared with an imported commercial cow feed. Milk production was 20% lower and feed cost 32% lower on the pineapple bran-molasses ration. No significant loss in body weight or in fat content of the milk occurred on the molasses feed.

114. Henke, L. A., and Goo, G. W. H., **Molasses added to**

**roughage increases milk production.** *Hawaiian Agr. Exp. Sta. Ann. Rpt.* **1937**:65-66. (1937).

In a third experiment conducted as previously described by these authors (1936), milk production was increased 4.5% by pouring molasses over the roughage feed.

**115.** HENKE, L. A., and MARUYAMA, C. I., **Value of molasses as a supplement to Napier grass.** *Hawaiian Agr. Exp. Sta. Ann. Rpt.* **1939**:26. (1939).

In a fourth 12-week double-reversal experiment with 8 cows, Napier grass was fed as roughage with and without added molasses. As in the previous studies, milk production and body weight were improved by adding the cane molasses.

**116.** HOPPE, P., **Value of molasses as food.** *Ztschr. Ver. Deut. Zuckerind.* **No. 535 II**:713-65. (1900); *J. Chem. Soc. (London)* **78**:681. (1900).

In experiments with cows, 5 Kg. of molasses per day was fed without injury to digestion. As a rule, the milk yield was increased and percentage of butterfat was decreased.

**117.** JONES, I. R., **Wood sugar molasses for dairy cattle.** *Oregon Agr. Exp. Sta. Circ.* **181**:1-12. (1949).

When given over a 12-week period to dairy heifers at the rate of 3 lbs. per cow per day, sprinkled over poor quality oat and vetch hay or grass hay, wood molasses compared favorably with cane molasses. The calculated TDN intake per lb. gain were 13.5 lbs. on the wood molasses and 13.2 lbs. on the cane molasses ration. From these results it is estimated that 100 lbs. wood molasses (56% dry matter) is equivalent to 77 lb. cane molasses of (75% dry matter). Both were very palatable to the cow.

**118.** KNODT, C. B., SHAW, J. C., and WHITE, G. C., **Studies on ketosis in dairy cattle. I. Effect of stall and pasture feeding upon the concentration of blood and urinary acetone bodies of dairy cattle.** *J. Dairy Sci.* **25**:837-49. (1942).

An increase in "ketone bodies" was observed in late winter in cattle receiving molasses grass silage. It is suggested that the increased production of acetone bodies is due to the feeding of aged molasses-silage and comes about because of the volatile acids in this silage.

119. Mather, R. E., and Bender, C. B., **Molasses as a replacement for grain in rations of growing heifers and milking cows.** *J. Animal Sci.* **10**:1056. (1951).

No significant differences in daily gains of heifers were noted when molasses replaced grain in the ration at a level of 4 lbs. daily; however, when molasses replaced one-half of the grain TDN, a marked reduction in total milk and butterfat production occurred. On the other hand, when molasses was fed ad libitum in addition to the full grain ration a slight increase in production resulted. Molasses consumption reached a maximum of 12.2 lbs. per day for one cow.

120. Mead, S. W., **Dried beet pulp and blackstrap molasses useful in dairy ration.** *New Jersey Agr. (New Brunswick).* **5**:5. (1923).

121. Monroe, C. F., Hayden, C. C., and Perkins, A. E., **Corn silage vs. a mixture of wet beet pulp and molasses for milk production.** *Ohio Agr. Exp. Sta. Bimonthly Bul.* **148**:3-8. (1931); *Ohio Agr. Exp. Sta. Spec. Circ.* **29**:40. (1930).

Sixteen cows were divided into groups and fed varying rations containing either corn silage or wet beet pulp mixed with molasses. Usually about 5% more milk and butterfat were produced when the cows received the wet beet pulp-molasses mixture than when they received corn silage.

122. *New Jersey Agr. Exp. Sta. Ann. Rpt.* **56**:28-32. (1935). **A study of dehydrated molasses in a dairy ration.**

In a series of trials, liquid and dehydrated cane molasses, were compared with each other and with a diet without molasses as to effects upon milk production. All diets were found to give approximately equivalent milk production.

123. Olschbaur, A., **Feeding experiments with molasses and sugar-beet residue.** *Deut. Landw. Presse.* **25**:966-7, 972-3. (1898).

An experiment is reported with 4 cows in which molasses residue was fed with and without added molasses, the rest of the ration being uniform. The two rations were about equal in value for the production of milk and fat, but the value of the manure from the cows receiving the molasses ration was somewhat greater, owing to the potassium content of the molasses.

124. Ramm, E., **The effect of various preparations of molasses (beet) on milk secretion.** *Landw. Jahrb.* **26**; No.4-5:733-65. (1897).

An experiment to study the effect of liquid molasses, molasses-peat feed (80% molasses, 20% peat), molasses and palm-nut meal, molasses and potato pulp, and a mixture of molasses and sugar beet difusion residue in comparison with barley. A basal ration of hay, straw and beets were fed. Only in the case of the liquid molasses was the whole quantity intended for the cow eaten readily. None of the molasses preparations appeared to be equal to barley for milk production. In a second experiment, 2 cows in the last months of pregnancy were fed 8 Kg. of molasses daily per 1000 Kg. live weight, and after calving the feeding was continued. There was no injurious effect from this feeding, either on the condition of the cow or the development of the calf.

125. Ramm, E., and Momsen, C., **The feeding value for milk cows of the solids—not—sugar in molasses.** *Milch Ztg.* **29**, No.28:433-6. (1900).

Results of an experiment with 5 cows indicated that molasses has a greater feeding value for dairy cows than sugar, and that the constituents of molasses, other than sugar, are especially valuable in the production of butter fat.

126. Roadhouse, C. L., and Henderson, J. L., **The influence of molasses and sodium chloride in dairy rations on the lactose and chlorine content and taste of milk.** *J. Dairy Sci.* 13:117-23. (1930); *California Agr. Exp. Sta. Rpt.* **1928-29**:65-6. (1930).

The maximum amount of molasses which cows would consume (5 to 6 lbs. per day) was added to basal ration of grain and alfalfa hay. This level did not increase the lactose content of the milk. It also did not influence taste of the milk.

127. Snell, M. G., Upp, C. W., and Lush, R. H., **Blackstrap molasses as a livestock feed. Blackstrap molasses for dairy cattle.** *Louisiana Agr. Exp. Sta. Circ.* 19:3. (1937).

Molasses was successfully fed to dairy cows in 2 experiments at the level of 3 lbs. per cow, diluted with an equal volume of water. Earlier experiments with calves showed that it could be used at a level of nearly 2 lbs. per calf per day or about 55% of the daily grain ration with good results. It is believed that molasses in excess of 3 lbs. per cow per day has a lower feeding value than corn.

128. Trowbridge, E. A., and Comfort, J. E., **The value of molasses as an appetizer when fed with drought corn fodder.** *Missouri Agr. Exp. Sta. Bul.* 370:14-15 (1936).

Molasses did not appear to improve the consumption of dry corn fodder by dairy cows.

129. Van Pelt, H. G., **How to feed the dairy cow.** *Kimball's Dairy Farmer.* 1916:740-1. (Nov. 15, 1916).

Brief descriptions of some of the European experimentation on the use of molasses and molasses feeds in rations for dairy cows.

130. Vries, J. J. O., De, **The feeding of molasses feed to dairy cattle.** *Verslag. Ver. Exploit. Proefzuivelboerderij Hoorn.* 1913:15-33. (1913); *Exp. Sta. Rec.* 34:671. (1916).

An experiment is reported in which molasses was fed to dairy cattle, resulting in a marked increase in yield of milk over those fed an ordinary hay ration. Milk from the cows receiving molasses was higher in both fat and dry matter content.

131. Wahlquist, R., **The value of molasses feed for milk cows.** *Nord. Mejerie Tidn.* 11:317-9. (1896).

A mixture of peat dust and molasses, 20:80, which is dry and is easily handled and is not sticky was fed to 6 Ayrshire cows at a level of 4 Kg. in addition to the Ultuna Agr. Institute regular summer feed. Six other cows received only the regular feed. Milk yield, weight gains and good health were maintained in both lots equally.

132. Ware, L. S., **Cattle feeding with sugar beets, sugar molasses, and sugar beet residuums.** Philadelphia, Philadelphia Book Co. (1902).

A book summarizing the results of American and foreign experiments. An excerpt (p. 240): "Molasses is apparently favorable to the production of milk, not only on account of the nutritive elements it contains, but also owing to the exciting action, due probably to the amide constituents, thereby causing an increase in the amount of milk per diem under certain conditions. With 2 to 4 per cent molasses the fatty substances remain almost stationary; but as soon as 5 kilos per head are fed per diem there is to be noticed a decrease in the fatty substances, which frequently attain 0.5 per cent, hence the importance of adhering to a certain standard within, reasonable limits. Without doubt, as before stated, the milk is of an exceptional quality."

133. Wayman, O., Iwanaga, I., Morita, K., Henke, L. A., Kenda, W., Lamb, A. R., and Doyle, B. K., **Sugar cane byproducts as major constituents of rations for dairy heifers, milking cows and beef steers.** *Hawaiian Agr. Exp. Sta. Progress Notes.* **No. 84.** (1952).

For dairy heifers, satisfactory growth was obtained using a diet containing 30% bagasse and 50% blackstrap molasses. These materials at the same levels of feeding failed to maintain satisfactory milk production in milking cows due to the high amount of bagasse.

134. Woll, F. W., and Humphrey, G. C., **Dried-beet pulp or molasses—beet pulp for dairy cows.** *Wisconsin Agr. Exp. Sta. Rpt.* **1905**:108-17. (1905).

Two tests with 15 and 6 cows, respectively, indicated that when wheat bran is valued at $18.00 per ton, dried beet pulp is not worth over $12.00 and molasses-beet pulp over $13.00 per ton.

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135. Woodward, T. E., Converse, H. T., Hale, W. K., and McNulty, J. B., **Values of various new feeds for dairy cows.** *U.S.D.A. Bul.* 1272:16. (1924).

In 2 trials with milking cows using a highly palatable and nutritious basal diet, it was found unnecessary (no differences were obtained) to supplement this already good ration with molasses. However, molasses was found to render poor quality feeds more palatable and induced a greater consumption and thereby greater milk production.

**Sheep and Goats**

136. Albert, F., **Investigation on molasses (beet) in different forms for fattening lambs.** *Landw. Jahrb.* 27:208-14. (1898).

All lambs received as basal ration per 100 Kg. live weight, 8 Kg. straw and chaff, 6 Kg. dried beet chips, and 5.5 lbs. rape-seed cake. Molasses was fed to 4 lots at varying levels and comparing mixing it in the feed with adding it to the drinking water. That mixed in the feed gave better results than that added to the drinking water. However, in all cases, the use of molasses was found to be advantageous.

137. Bell, D. S., **Molasses for fattening lambs.** *Ohio Agr. Exp. Sta. Bul.* 497:127-8. (1932).

Two lots of 25 lambs each were fed: (1) a basal ration of shelled corn, protein supplements, mixed clover hay, and corn silage; (2) same as (1) plus 0.25 lbs. of cane molasses replacing an equal amount of corn. The test was conducted to determine whether or not molasses causes urinary calculi in lambs. None of the lambs evidenced symptoms to indicate the presence of urinary calculi. Post mortem examinations also failed to reveal the presence of calculi.

138. Clark, R., and Quin, J. I., **Studies on the alimentary tract of the Merino sheep in South Africa; effect of supplementing poor quality grass hay with molasses and nitrogenous salts.** *Onderstepoort J. Vet. Res.* 25:93-103. (1951).

139. Evvard, J. M., Culbertson, C. C., Wallace, Q. W., and Ivins, S. S., **Experimental results in feeding cane and beet**

**molasses to fattening lambs.** *Iowa Agr. Exp. Sta. Bul.* **215**:369-400. (1923).

Seven lots of 30 lambs each were fed: (1) Basal diet, hand-fed shelled corn, linseed oil meal, corn silage and clover or alfalfa hay; (2) basal diet plus 0.25 lbs. cane molasses per head per day; (3) basal diet plus 0.5 lbs. cane molasses per head per day; (4) basal diet and all the cane molasses the lambs would eat during their 2 daily feedings; (5) 0.25 lbs. beet molasses; (6) 0.5 lbs. beet molasses; and (7) full-fed beet molasses twice a day. The average daily gains were: (1) 0.290, (2) 0.313, (3) 0.366, (4) 0.355, (5) 0.323, (6) 0.391, and (7) 0.384 lbs. over an 80-day period.

**140.** Fingerling, G., **Further investigations on the influence of stimulating substances on milk secretion.** *Landw. Vers. Stat.* **74**:163-82. (1911).

Three goats were fed a mixture of malt sprouts, starch, sesame cake, meadow hay and salt, a highly palatable feed. Larger milk yields were obtained on this ration than on one consisting of less palatable materials such as peanut oil, starch, gluten, feed lime, hay ash and straw unless the latter ration was supplemented with molasses. The author concluded that the differences in milk yield were due to differences in palatability.

**141.** Holden, J. A., **Lamb feeding experiments in western Nebraska.** *Nebraska Agr. Exp. Sta. Bul.* **194**:35. (1923).

Molasses with alfalfa hay or alfalfa hay alone were unsatisfactory rations for lambs.

**142.** Linfield, F. B., **Experiments in fattening lambs.** *Utah Agr. Exp. Sta. Bul.* **78**:55. (1902).

Six lbs. of alfalfa hay plus 3.87 lbs. of wheat screenings were required per lb. of gain. Under similar condition 1.42 lbs. of beet molasses plus 1.5 lbs. of bran, together with 8.1 lbs. of alfalfa hay produced a lb. of gain.

**143.** Maynard, E. J., **Beet by-products for fattening lambs.** *Colorado Agr. Exp. Sta. Bul.* **266**:12. (1921).

Comparing 4 lots of 32 lambs each, the following diets were used: (1) corn, alfalfa; (2) corn, beet molasses, alfalfa; (3) barley, beet molasses, alfalfa; and (4) oats, beet molasses, alfalfa. The average daily gains were: (1) 0.334, (2) 0.347, (3) 0.314, and (4) 0.323 lbs. over a 93-day experimental period.

144. Morton, G. E., **Experiments with sheep at Colorado station.** *Colorado Agr. Exp. Sta. Rpt.* 1929:16-7. (1929).

In comparative tests of different kinds of molasses in lamb-fattening rations containing shelled corn and alfalfa hay, it was found that Steffens discard molasses was slightly more efficient than beet molasses and cane molasses, but that the results with all three were quite comparable.

145. Neale, P. E., **The use of cottonseed meal, cottonseed hulls, and molasses in fattening rations for New Mexico range lambs.** *New Mexico Agr. Exp. Sta. Bul.* 200:1-11. (1932).

The addition of cane molasses increased the rate and economy of gains, eliminated death losses, and improved the general health and appearance of lambs when compared with lots which received rations of cottonseed meal and hulls without molasses.

146. Ramm, E., **Sheep-feeding experiments with molasses.** *Deut. Landw. Presse.* 23, No. 73:651-2. (1896).

Three lots of 2 lambs were fed: (1) 1.4 Kg. of hay, 1 Kg. bean meal, and 3.6 Kg. of molasses per 100 Kg. live weight; (2) 1 Kg. hay, 1 Kg. bean meal and 4.5 Kg. peat molasses cake; (3) 1 Kg. hay, 1 Kg. bean meal and 2.8 Kg. barley meal. In spite of the fact that during the following 7 months, lot (3) gained somewhat more than lots (1) and (2), the experimenter, after slaughtering and selling the carcasses, tallow and fleece, lost money on lot (3) and made money on lots (1) and (2).

147. Scharrer, K., and Nebelsiek, H., **Digestibility of soybean straw and soybean straw-molasses mixtures with sheep.** *Z. Tierernahr. Futtermittlek.* 1:72-81. (1938).

Both soybean straw and soybean straw meal were markedly

improved, as regards digestibility and palatability, by the addition of molasses.

148. Shaw, R. S., **Dried beet pulp and dried molasses-beet pulp for fattening sheep.** *Michigan Agr. Exp. Sta. Bul.* 220:43-50. (1904).

The tests indicated that both dried beet pulp and dried molasses-beet pulp possessed feeding values comparing favorably with corn.

149. Taylor, F. W., **Feeding experiments.** *New Hampshire Agr. Exp. Sta. Rpt.* 1907-08:322-4. (1908).

Two lots of 4 yearlings and 4 aged ewes each were used to compare molasses with corn meal as a supplementary ration for sheep. The basal ration consisted of wheat middlings, oats and second crop clover. The experimental period was 60 days. The lot which received molasses made a daily gain 1.4 times that made by the lot receiving corn meal and the gain was made 1.5 times more economically.

150. Velu, H., and Boutrois, M., **Intoxication by molasses and analyses of stomach contents.** *Bul. Acad. Vet. France.* 12: 289-91. (1939); *Biol. Abst.* 14:644. (1940).

Some sheep being fed molasses and molasses products showed steady mortality. Chemical analyses of the molasses, and stomach contents failed to show the cause of the trouble.

151. Weber, A. D., and Fox, H. D., **Alfalfa-molasses meal for fattening lambs.** *Nebraska Agr. Exp. Sta. Bul.* 259:1-12. (1931).

In a series of experiments, corn, linseed meal and alfalfa were compared with and without cane or beet molasses. The results with the two types of molasses were equivalent and were equal to or better than the results obtained without added molasses.

**Molasses Feeds, Ammoniated Molasses, and Molasses with Urea**

152. Albert, F., **Deep stalls and ordinary stalls for steers,**

together with feeding experiments with molasses peat and molasses bran. *Landw. Jahrb.* 27:174-88. (1898).

Comparing these two "molasses feeds" with steers receiving a diet furnishing 3.08 Kg. digestible nitrogenous matter and 17.28 Kg. nitrogen free material, the molasses feeds were about equal.

153. Anonymous, **Molasses as stock feed.** *Demeter.* 2:26-7. (1904).

The manufacture, feeding value, and importance of molasses feeds is briefly discussed. One of the best absorptive materials for use with molasses is finely ground bagasse. "From it and molasses a food can be made that has 70% of digestible carbohydrates."

154. Arnold, C. D., **Feed mixtures containing molasses.** U.S. Patent. 1,996,395. (1935).

Small particles of vegetable matter such as green alfalfa are treated with hygroscopic molasses so as to withdraw water from the cells of the material and impregnate the material with molasses, and the mixture is dehydrated.

155. Ayyar, N. K., and Zubery, W. W., **Bagomolasses as cattle feed. 2. The use of bagomolasses for feeding working bullocks.** *Indian J. Vet. Sci.* 15:140-6. (1945).

The health and working capacity of working bullocks receiving bagomolasses to the extent of 18 to 27% of the dry matter compared well with those of the control animals during a short-term experiment, using 24 bullocks.

156. Bartz, J. P., (to Ralston Purina Co.) **Stock food from molasses.** U.S. Patent. 1,940,837. (1933).

For changing a body of molasses from a liquid to a jelly-like state, the molasses is heated then mixed with a solution of a jellifying material such as agar agar or gelatin in water, the mixture (or the molasses) is dehydrated sufficiently that the mixture has no greater water content than the untreated molasses, and the mixture is allowed

to cool. The product thus prepared, is suitable for mixing with various other stock feed ingredients.

157. Beeson, W. M., **Corn cobs, molasses and urea for cattle feeding.** *Flour & Feed.* **51,** No. 5:22-3. (1950); *Feedstuffs.* 22(47):20-1. (1950).

Molasses is suggested for use with corn cobs to increase their palatability and to supply available carbohydrates. Basis for widely publicized Purdue "Formula A."

158. Beeson, W. M., and Perry, T. W., **Balancing the nutritional deficiencies of roughages for beef steers.** *J. Animal Sci.* **11**:501-15. (1952).

In order to make use of low-quality roughage material, such as corn cobs, the author's worked out a balanced supplementary feed known as Purdue Cattle Supplement A. This supplement contained soybean meal to provide readily available protein, molasses to provide necessary minerals and sugar for use by the cellulose-splitting rumen micro-organisms, together with bonemeal, salt and a vitamin A and D concentrate. The composition of Formula A is as follows: Soybean meal, 643.1; molasses (45% molasses and oat hull mixture), 285.8; bonemeal, 51.4; salt, 17.2; and vitamin A and D concentrates, 2.5 lbs. per 1000 lbs. Each steer received 3.5 lbs. of this supplement daily together with corn cobs, oat straw, soybean straw, corn silage or grass silage as the sole sources of roughage. Daily gains were: ground corn cobs, 1.28 to 1.56 lbs.; oat straw, 0.78 lb.; soybean straw, 0.78 lb.; corn silage, 2.06 to 2.21 lbs.; grass silage, 2.01 lbs. per steer per day. The addition of alfalfa meal resulted in a significantly greater growth rate.

159. Bowstead, J. E., and Fredeen, H. T., **Feeding urea to dairy cows with special reference to the palatability of feed mixtures containing urea.** *Sci. Agr.* 28:66-78. (1948).

Of all methods tested, the addition of molasses appeared to be much the best method of improving the palatability of feed mixtures containing either 2 or 3% urea.

160. Cranfield, H. T., and Mackintosh, J., **Taint in milk**

during the feeding of molassed beet pulp. *J. Minist. Agric. Lond.* 42:551-60. (1935).

Certain samples of dried molassed beet pulp (usually dark in color) appeared to produce a "taint" in milk of certain cows.

161. Culbertson, C. C., **Molasses feeding tests.** *Flour & Feed.* 51, No. 7:26. (1950).

Using a well-balanced basal ration, a urea feed and an ammoniated molasses were compared as replacements for (1) one-half the protein feed (linseed meal) and (2) all of the protein feed. It appeared that ammoniated molasses and urea-molasses were on a par as a partial substitute for the protein supplement, both giving excellent results in fattening steers.

162. Culbertson, C. C., Shearer, P. S., Hammond, W. E., and Moore, S., **Molasses feeding tests.** *Iowa Agr. Exp. Sta. Ser. A.H.* 176. (1950).

For abstract see No. 170.

163. Experiment Station Notes, **Molasses as food for animals.** *Experiment Station Record.* 4:452. (1892/93).

A review is given of a lecture by a Prof. Maercker, who recommends the feeding of beet molasses mixed with sugar beet diffusion residue. He states that fattening sheep may be given 8 lbs. of molasses per 1000 lbs. of live weight, oxen 3 to 4 lbs. and milking cows about 2.5 lbs. per 1000 lbs. live weight, but that care should be exercised in feeding it to cows with calf. The molasses should be fed mixed with dried beet diffusion residues in every case.

164. Experiment Station Notes, **Feeding stuff from molasses.** *Experiment Station Record.* 4:620. (1892/93).

A commercial concern in Cothen, Germany produced a feeding stuff by mixing certain materials with beet-molasses yielding a dry, mealy food. Experiments with this material conducted by farmers are said to have given excellent results.

165. Friis, F., **Feeding experiments with molasses feed.** *Landmansblade.* 29:647-8. (1896).

In feeding experiments with cows and pigs conducted at the Danish State Experiment Station, Copenhagen, molasses feed (palm-nut meal, wheat bran and molasses, 1:3:4) proved, in general, equally valuable, pound for pound, as grain feeds. No deleterious results were noted in dairy cows, even when 4 to 5 lbs. of molasses feed was fed per day.

166. Ganchev, Z., and Popov, I., **Composition, digestibility and feeding value of molasses feeds manufactured in Bulgaria.** *Ann. Univ. Sofia. V. Faculte agron. sylviculture.* 11:435-58. (in German, 459-62). (1933).

167. Garola, C. V., **Report on molasses feeds.** *Compt. Rend. Cong. Soc. Aliment. Rat. Bet.* 6:1-15. (1902).

Mixtures of molasses with peat, peanut hulls, sesame and peanut hulls, and with straw are described and the favorable and economical results of feeding these to sheep and horses are noted.

168. Gasper y Arnal, T., **Treatment of molasses for the production of foods, feeding stuffs and fertilizers.** *Chimie & industrie.* 34:931. (1934); *Agricultura* (reprint) 1934 (Aug-Sept); *C.A.* 30:1140. (1936).

Beet molasses keeps indefinitely when undiluted. However, upon dilution to a concentration of about 20% it rapidly acquires a repugnant odor and taste. To prevent this decomposition, ammonia, amines, Rb, Cs, and other materials are removed by treatment with $K_4Fe(Cn)_6$. The excess reagent is removed by manganese sulfate. The Mn is then recovered by treating with CaO.

169. Grandeau, L., **New molasses products in the feeding of farm animals.** *J. agr. prat.,* n. ser. 5, no.19:592-3. (1903).

170. Halligan, J. E., **American molasses feeds: their manufacture and composition.** *Ind. Eng. Chem.* 1:441-5. (1909).

The various kinds of molasses feeds, the methods of preparation and analyses of representative samples are given.

171. Hannson, N., **Molasses and molasses feeds for horses and dairy cows.** *Centralamst. Forsok, Jordbruksomradet.* **No. 29.** (1911); *Zentr. Agr. Chem.* **40**:54. (1911); *Deut. Zuckerind.* **36**:208. (1911); *C. A.* **5**:2130. (1911).

For cows, 1.3 Kg. of molasses (50% sugar) was equivalent to 1 Kg. of barley or Indian corn. For horses, molasses had a somewhat higher value.

172. Haution, R., **Chaff-molasses mixture.** *J. agr. prat.* **99**:88-9. (1935).

Forage deficiency can be supplied by chaff soaked with molasses. A mixture of 1 Kg. of molasses (50% sugar) and 1 Kg. chaff has an energy value equivalent to 2.5 Kg. of good meadow hay.

173. Hollrung, M., **Use of molasses for feeding.** *Ztschr. Zuckerind.* **44**:580. (1894). *Chem. Ztg.* **18**, no.70:214. (1894).

The author claims very favorable results from feeding a "molasses feed" prepared by mixing heated molasses (70 to 75° R.) with an equal weight of freshly ground palm-nut cake. The animals must be allowed to become accustomed to the feed gradually.

174. Kehar, N. D., **Investigations on famine rations for livestock. 1. Munj and molasses as famine rations.** *Indian J. Vet. Sci.* **14**:40-8. (1944).

In experiments with bulls and young calves, munj grass, moistened with water and fed with rape cake, to which molasses was added, together with some wheat bran, all animals gained weight and remained in good health.

175. Kellner, O., Zahn, O., and Von Gillern, H., **Feeding experiments with molasses and ground peat.** *Landw. Vers. Stat.* **55**, No.4-5:379-88. (1901).

The authors conclude that ground peat is not only indigestible, but also decreases the digestibility of other foodstuffs, including molasses.

176. Knodt, C. B., Williams, J. B., and Brumbaugh, J., **Ammoniated cane molasses and similar products in the rations of dairy calves.** *J. Dairy Sci.* **34**:1042-6. (1951); *J. Animal Sci.* **9**:661-2. (1950).

Ammoniated molasses, fed as a replacement for the nitrogen of soybean meal and oats in the ration of Holstein bull calves, acted as a satisfactory substitute after the calves were 15 to 16 weeks of age. Nitrogen from $NH_3$ could not be used before the calves were 12 weeks of age and only in limited quantities from the 12th to 16th week.

177. Liefeld, B. F., **New food for livestock in Germany.** *U. S. Consular Rpt.* **71**:79-80. (1903).

The manufacture and use of blood-molasses feed is described.

178. Lindsey, J. B., **The examination of cattle and poultry foods.** *Massachusetts Agr. Exp. Sta. Bul.* **112**:58. (1905).

(Many earlier similar reports by this author have mentioned molasses feeds usually together with some derogatory comment regarding their value as a feed for cattle.) In the present report he states "The better grades of molasses feeds test rather higher in protein than formerly, are readily eaten, and can be safely fed as the entire grain ration for cattle if desired".

179. Maclachlan, J. C., (to Albert P. Hunt), **Dried molasses product.** U. S. Patent. 1,897,729. (1931).

In forming a product suitable for use as a stock feed, molasses is mixed with ground alfalfa meal and the mixture is spray-desiccated.

180. Magruder, N. D., Knodt, C. B., and Williams, P. S., **The value of ammoniated industrial by-products in the rations of dairy cattle.** *J. Animal Sci.* **10**:1055. (1951).

Ammoniated cane molasses was compared with various other ammoniated molasses products and a urea ration upon milk pro-

duction and growth in dairy cattle. Milk production, weight gains and digestibility were not significantly different from controls.

181. Malet, G., **Preparation and use of molasses bread for cattle feeding.** *B. Zuckerrubenbau.* 9:295-9. (1902).

Two kinds of "molasses bread" are described. This product was found to cause weight gains in horses, cattle and swine. It had no influence on quality or quantity of milk in dairy cows.

182. Nicolas, L., **Report on the use of molasses in the feeding of animals.** *Compt. Rend. Cong. Soc. Aliment. Rat. Bet.* 6:16-25. (1902).

In experiments with 10 cows lasting 2 months it was found that the addition of phosphoric acid to the molasses feed overcame the depression of milk yield observed with the molasses feed without the acid.

183. Pfeiffer, T., and Einecke, A., **The digestibility of peat as an absorbent for molasses in molasses feed.** *Mitt. Landw. Inst. Univ. Breslau.* 2, No.4:683-94. (1904).

The authors call attention to the fact that molasses-peat has more value than is ordinarily believed.

184. Ray, S. C., and Talapatra, S. K., **Bagomolasses as cattle feed. 1. Digestibility and nutritive value of bagomolasses.** *Indian J. Vet. Sci.* 15:133-140. (1945).

Cattle showed little sustained appetite for bagomolasses alone, but readily accepted it when mixed with wheat bran and well soaked with water. The associated diuresis, presumed to be due to the high potassium content, could be offset by adding sodium chloride to the diet.

185. Reiner, H. C., **Non-hygroscopic dehydrated molasses mixture suitable for use in stock feeds.** U. S. Patent. 1,995,519. (1935).

Pulverized limestone is mixed with a powdered, substantially

dehydrated molasses residue to form a substantially non-hygroscopic and non-agglomerating material.

186. Rosam, W., **A feeding stuff made from molasses and seed-beet litter.** *Osterr. Ungar. Ztschr. Zuckerind u. Landw.* 32:947. (1903); *Centbl. Agr. Chem.* 33:703-4. (1904).

The keeping qualities and analysis of this feedstuff are reported. A brief report on tests with this material using milk cows is also included.

187. Saillard, E., **The production of pressed foods from dried beets and molasses.** *Suppl. Circ. Hebd.* No. 2081. (1929); *Listy Cukrovar. Rozhledy.* 47:36. (1929); *C. A.* 23:4748. (1929).

A mixture of 75% dried beet slices and 25% molasses is pressed into briquets at a pressure of 120-150 atmospheres. The briquets are easily handled and measured out in feeding. Upon being placed in water they fall apart and make an excellent cattle feed.

188. Saillard, E., **Cane molasses and molasses feeds.** *Suppl. Circ. Hebd. Comite central fabr. sucre.* 43. (Dec. 20, 1931); *Chimie & industrie.* 27:1442. (1932); *C. A.* 26:4389. (1932).

The author suggests treating molasses and molasses feeds with sufur dioxide in order to inhibit fermentation and thus ensure proper keeping. He claims the treatment to be harmless to cattle.

189. Savage, E. S., **Oat feed and molasses.** *Flour & Feed.* 39, No. 5:16. (1938).

It is suggested that a highly nutritious and palatable feed could be made by mixing oat mill feed with molasses.

190. Sawter, G., **Cattle food from sugar cane in the West Indies.** *U. S. Consular Rpt.* 69. No.263:562. (1902).

A brief note on a cattle feed called "molascuit" made from molasses and bagasse.

191. Schulze, B., **The preservation and value of mixed molasses feeds.** *Arb. Deut. Landw. Gesell.* **No. 59**:26. (1901).

The composition of a number of corn germ-molasses feeds and peat-molasses feeds is reported. The sugar was found to undergo loss and inversion, especially in summer.

192. Stein, V., **Molasses feed.** *Landmansblade.* **29**:1-4. (1896); *Exp. Sta. Rec.* **8**:246. (1896/97).

The feed is made from palm-nut meal, wheat bran and molasses (beet) in the proportions 1:3:4. It is recommended to begin feeding with small quantities, gradually increasing to levels of 8 to 10 lbs. per 1000 lbs. weight per day for milk cows; 0.5 to 3.3 lbs. per head for young cattle; about 4.5 lbs. for horses; 1 to 1⅜ lbs. per 100 lbs. live weight for sheep and 1 to 2 lbs. per 100 lbs. live weight for hogs.

193. Stiles, H. R., (assigned to Comm. Solv. Corp.). U. S. Patent. 2,603,567. (1952); *Official Gaz. U. S. Pat. Off. 660;* **3**:741. (1952).

Ammonia is caused to react with sugar from such crude materials as blackstrap molasses, hydrol syrup, wood sugar syrup and citrus and distiller's molasses to form a nitrogenous material suitable for feeding cows and other ruminants. In this manner, molasses can be given a protein equivalency of at least 15-30%, perhaps higher, converting it to a "high-protein" feed for ruminants.

194. Tillman, A. D., Kidwell, J. F., and Singletary, C. B., **Ammoniated condensed distillers molasses solubles as a feed for beef cattle.** *Louisiana Agr. Exp. Sta. Ann. Rpt.* (1950/51).

Two experiments using 3 lots of 5 calves in each were conducted to compare the effect of replacing 25% and 50% of the molasses in a normal calf ration with equal amounts of ammoniated molasses distillers solubles (condensed). No significant differences were obtained. However, there was an indication that the 56-day feeding trial may not have been long enough to show the full effect after the rumen microflora had changed and become geared to the new feed.

**195.** Tillman, A. D. Singletary, C. B., Kidwell, J. F., and Bray, C. I., **Methods of feeding cane molasses and urea to beef cattle.** *J. Animal Sci.* **10**:939-46. (1951).

Forty steers were divided into 5 equal groups. Four groups received molasses, 1 group no molasses. Two of the 4 groups received liquid molasses and two received dehydrated molasses feeds (one dried on cottonseed hulls and the other on bagasse). All animals receiving liquid molasses made satisfactory gains, but those on dried molasses did not. These results were duplicated in a second experiment. This experiment was then extended to study urea, which was dissolved in the molasses at 2 levels to provide 51.3% of the protein in the concentrate or 43.2% of the protein in the total ration and 62.7% and 53.2% respectively. Similar gains and gains not significantly different, though slightly lower, than those on the control ration were obtained with both urea rations. Urea did not alter the palatability of the molasses.

**196.** Tillman, A. D., and Swift, R. W., **The utilization of ammoniated industrial by-products and urea by sheep.** *J. Animal Sci.* **11**:777. (1952); **12**:201-12. (1953).

Ammoniated cane molasses was compared with urea and soybean meal as sources of nitrogen for sheep. At a level of 10%, by weight, of the ration the ammoniated molasses was palatable and resulted in satisfactory growth. However, the digestibility of all ration constituents except ether extract was reduced by the addition to the ration of ammoniated molasses.

**197.** Vallier, *R.*, **Molasses fodder.** *Rev. gen chim.* **13**:367. (1911); *C. A.* **5**:1133. (1911).

With dried peat, a fodder containing as much as 75% molasses can be prepared, which is not hygroscopic.

**198.** Van De Venne, H., **Molasses in mixed feeds.** *L'Ing. Agr. Gembloux.* **12**, No.9:437-48. (1902).

The composition of a number of molasses feeds is given and their nutritive value discussed.

199. Wendeler, P., **Dried sugar-beet pulp and molasses.** *Deut. Zuckerind.* 58:689-90, 710-12. (1933); *C. A.* 27:5568. (1933).

The absorption of an equal weight of molasses by extracted cossettes was followed by extracting the mixture at intervals with water at room temperature. (a) For 1-2 minutes to remove surface syrup and then (b) for 2 hours to remove soluble constituents from the interior.

200. Willett, E. L., Henke, L. A., and Maruyama, C. I., **Urea in dairy cow rations.** *Hawaiian Agr. Exp. Sta. Bien. Rpt.* 1944/46:33-35. (1946).

In previous studies it was found that when urea was used in place of protein for dairy cows a drop in milk production resulted. Since the diets used in these studies contained 25% molasses, the present study was conducted to determine whether this large amount of molasses had a detrimental effect upon the ability of the cows to utilize urea. Four cows were divided into 2 groups. Both groups received urea, but only one received 25% molasses. The average milk production in terms of 4% fat-corrected milk were 21.3 and 21.2 lbs. per day.

201. Willett, E. L., Henke, L. A., and Maruyama, C. I., **The use of urea in rations for dairy cows under Hawaiian conditions.** *J. Dairy Sci.* 29:629-37. (1946).

The feeding of cane molasses in amounts up to 25% of the concentrate mixture for Holstein Friesian cows had no detrimental effect upon the synthesis of protein from urea in the rumen.

202. Zenzes, A. M., U. S. Patent. 2,430,797. (1947).

Molasses is mixed with finely divided, edible fibrous material such as powdered bagasse or other grasses or cereal straws to yield an apparently dry, free-running product which is useful in the food industry and for animal feed.

**Molasses and Rumen Digestion**

203. Arias, C., Burroughs, W., Gerlaugh, P., and Bethke,

R. M., **The influence of different amounts and sources of energy on in vitro urea utilization by rumen microorganisms.** *J. Animal Sci.* **10**:683-92. (1951).

Effects of dextrose, sucrose, starch, cellulose and ground corn cobs were compared with molasses as sources of energy and its effect on conversion of urea nitrogen into bacterial protein *in vitro*. Small amounts of readily available energy such as in molasses aided in cellulose digestibility which in turn increased urea utilization. Large amounts of available carbohydrate inhibited cellulose digestion.

**204.** Briggs, H. M., **The effect of molasses on the digestibility of a lamb fattening ration.** *Proc. Am. Soc. Animal Production.* **30**:145-9. (1937); *Oklahoma Agr. Exp. Sta. Rpt.* **1936/38**:63. (1938).

Rations of corn or oats and alfalfa hay were fed with and without added blackstrap molasses to lambs. The addition of molasses reduced, somewhat, the digestibility of protein and fat in the rations, but did not affect the digestibility of other constituents. All lambs gained weight during the experiment.

**205.** Briggs, H. M., and Heller, V. G., **The effect of adding blackstrap molasses to a lamb-fattening ration.** *J. Agr. Res.* **60**:65-7. (1940).

In a series of digestion trials the substitution of molasses for one-half the grain (corn in some trials and oats in others) caused a slight to barely significant decrease in digestibility of protein; a highly significant decrease in digestibility of fat, but no significant change in digestibility of fiber or NFE with one exception in which the digestibility of NFE was highly significantly increased by adding molasses.

**206.** Briggs, H. M. and Heller, V. G., **The effect of adding blackstrap molasses, K salts, sucrose and corn syrup to a lamb-fattening ration.** *J. Agr. Res.* **67**:359-67. (1943).

Substitution of molasses for one-half of the corn in a fattening ration decreased the coefficient of apparent digestibility for protein, fat and nitrogen-free extract. Potassium salts did not decrease

digestibility as much. Therefore, minerals do not appear to be the only cause of the decreased digestibility observed with molasses.

207. Briggs, H. M., and Heller, V. G., **The tolerance of lambs to varying levels of blackstrap molasses.** *J. Animal Sci.* 2:364-5. (1943).

In a ration consisting of corn, 410 gms.; cottonseed cake, 44 gms.; and ground alfalfa hay, 454 gms. a part of the corn was replaced by 5, 10 and 15% blackstrap molasses. Apparent protein digestibility coefficient remained almost the same, slightly reduced at 15% molasses level. The apparent fat digestibility coefficients were 66.8%, 65.9%, 64.4 and 60.9% for 0, 5, 10, and 15% molasses. The levels of 5 to 15% molasses produced no consistent alterations of the apparent digestibility coefficients of fiber and NFE.

208. Briggs, H. M., and Heller, V. G., **Tolerance of lambs for blackstrap molasses.** *J. Agr. Res.* 71:81-7. (1945).

An experiment to determine the amount of molasses usable before digestibility coefficients are reduced. Molasses substituted for corn at 5, 10 and 15% in a basal ration of corn, cottonseed meal and alfalfa hay. Digestibility of protein was decreased only at the 15% level; fat at both 10 and 15% levels; fiber and NFE were not influenced significantly by molasses at any of the levels. Thus, there was no lowering of digestibility at the 5% level. However, digestibility, even at the 15% level, was not sufficiently reduced to exclude it as a most economical feedstuff for use at this level.

209. Briggs, H. M., Heller, V. G., and Wall, R., **Molasses reduces digestibility of other components of rations.** *Oklahoma Agr. Exp. Sta. Bien. Rpt.* 1938/40:62. (1940).

In a ration containing oats or corn and alfalfa hay, molasses appeared to lower the digestibility of protein slightly and of fat about 17-18%. However, at the level fed, molasses replaced an equal amount of corn or oats in the ration.

210. Burroughs, W., Latona, A., Depaul, P., Gerlaugh, P., and Bethke, R. M., **Mineral influences on urea utilization**

**and cellulose digestion by rumen microorganisms, using the artificial rumen technique.** *J. Animal Sci.* 10:693-705. (1951).

The ashes of molasses, immature clover, and mature timothy hay were approximately equal in stimulating urea utilization. P and Fe were effective in stimulating cellulose digestibility and urea utilization.

**211.** Burroughs, W., Long, J., Gerlaugh, P., and Bethke, R. M., **Cellulose digestion by rumen microorganisms as influenced by cereal grains and protein-rich feeds commonly fed to cattle using an artificial rumen.** *J. Animal Sci.* 9:523-30. (1950).

Cellulose digestion in artificial rumens was influenced favorably by: Dried distillers solubles, soybean oil meal, linseed oil meal, cane molasses, corn, wheat bran, and cottonseed meal in that order. Feeds showing little or no favorable influence upon artificial rumen microbiological digestion were meat scrap, fish meal, liver meal and oats.

**212.** Claassen, H., **Molasses; feed value and buffering.** *Centr. Zuckerind.* **45**:179-80. (1937); *C. A.* 31:3730-31. (1937).

About one-third of the total nitrogen in beet molasses is assimilable by ruminants. The author indicates that beet molasses contains a stronger buffering capacity than cane molasses.

**213.** Colovos, N. F., Keener, H. A., and Davis, H. A., **The effect of pulverized limestone on the digestibility of the protein and the energy in silage.** Preliminary report presented at Am. Dairy Sci. Assn. Eastern Meeting, Sept. 16, 1951.

It was considered possible that the lowered digestibility of molasses silage is due to its acidity and that neutralization with pulverized limestone might improve digestibility. In a number of energy and protein balance experiments with dairy heifers it was found that added limestone reduced digestibility significantly.

**214.** Colovos, N. F., Keener, H. A., Prescott, J. R., and Terri, A. E., **The nutritive value of wood molasses as com-**

pared with cane molasses. *J. Dairy Sci.* 32:907-13. (1949); *Flour & Feed.* 50, No.12:24. (1950).

Twelve protein and energy digestion balance experiments were conducted with dairy heifers. Wood molasses excelled cane molasses in gross energy by about 10% on the dry basis. Metabolizable energy was about the same in both kinds of molasses. Total digestibility as well as metabolizability of energy was increased by both types of molasses. Cane molasses depressed protein digestibility by 4.8%; wood molasses by 12.1%.

215. Fraps, G. S., **Digestion Experiments.** *Texas Agr. Exp. Sta. Bul.* 104:33. (1908).

Using steers as subjects the author found that the nitrogen free extract of molasses is highly (104.6%) digestible.

216. Gerland, K., **Comparative tests of the effect of beet molasses and molasses preparations in animal feeding.** *Ber. Physiol. Lab. Landw. Inst. Halle.* 3:1-55. (1901).

In digestibility trials with sheep it was found that good results were obtained when 4 Kg. molasses was used per 1000 Kg. live weight, but decreased digestibility of the other feeding stuffs was pronounced when 4.8 Kg. to 5 Kg. of molasses were fed.

217. Hamilton, T. S., **The effect of added glucose upon the digestibility of protein and of fiber in rations for sheep.** *J. Nutr.* 23:101-110. (1942).

Using 6 sheep and the double reversal method of feeding, the effect of corn sugar upon digestibility of the ration was studied. The sugar increased the apparent digestibility of dry matter, nitrogen-free extract and total carbohydrates. It decreased the apparent digestibility of total nitrogen but had no effect upon true digestibility since the apparent decrease could be accounted for by the estimated increase in metabolic nitrogen in the feces of the sheep. The digestibility of the fiber was decreased, indicating a preferential use of sugar by the rumen microorganisms.

218. Honcamp, F., **The utilization of sugar and sugar-con-**

taining foodstuffs as fodder by domestic animals. *Tiererrnahrung.* 1:388-407. (1930).

The ratio of the efficiency of starch to sugar was found to be 100.76 for cattle; 100.79 for fattening of swine. On the basis of this, it is suggested that molasses is a suitable feedstuff.

219. KLEIN, W., SCHMID, H., and STUDT, E., **The biological process of the utilization of the amides of molasses and straw protein in the ruminant.** 3. *Tierzucht. u. Zuchtungsbiol. (Ztschr. Zuchtung Reihe B.)* **39**:135-61. (1937).

Sheep were able to grow and were kept for 2 years and successfully reproduced on a ration of molasses, straw and starch. This ration contained most of its nitrogen as non-protein-nitrogen.

220. KLEIN, W., SCHMID, H., and STUDT, E., **Utilization of mixtures of molasses and amides by ruminants. Partial replacement of amides by nitrogenous compounds capable of being produced on an industrial scale.** *Tierzucht u. Zuchtungsbiol. Reihe B.* **40**:404-6. (1938).

A brief note is given on experiments with rations of low nitrogen content and the use of ammonium salts. A 50 Kg. sheep was kept in positive nitrogen balance on a ration containing molasses and supplying over one-half the nitrogen from $NH_4$ salts. This is explained as "zymogenic symbiosis" in the rumen from ammonium salts and organic acids.

221. KLEIN, W., SCHMID, H. STUDT, E., and MULLER, R., **Biological value of the bacterial protein produced from non-protein compounds in the rumen based on the established physiological protein minimum. Fermentation in the rumen: its significance for deficiency symptoms.** *Ztschr. Tierzucht. u. Zuchtungsbiol.* **43**:76-119. (1939).

Five sheep were kept in nitrogen equilibrium and good health over long periods on rations of straw, chaff, starch and molasses, supplying 410 g. digestible protein per 1000 Kg. live weight, of which not more than 40 to 60 g. came from straw. The bacterial

proteins produced from the "amides" of the molasses by zymogenic symbiosis in the rumen proved equal in biological value to a mixture of gluten and hay protein.

222. Lindsey, J. B., Holland, E. B., and Smith, P. H., **The digestibility of cattle foods.** *Massachusetts Agr. Exp. Sta. Rpt.* 1906:96-156. (1906).

In digestibility trials with sheep, in 6 tests, it was concluded that "2,000 lbs. of Puerto Rico molasses contain between 1,080 and 1,160 lbs. of easily digestible carbohydrates, and that its crude protein has little or no value as a source of nutrition".

223. Lindsey, J. B., and Smith, P. H., **Effect of Puerto Rico molasses on digestibility of hay and of hay and concentrates.** *Massachusetts Agr. Exp. Sta. Rpt.* 1909. Pt.1:82-131. (1909).

Experiments with sheep indicated that when cane molasses constituted from 10 to 13% of the dry matter of a hay and molasses ration it was without effect upon digestibility of the hay. Twenty per cent solids as molasses, however, depressed digestibility. On a ration of hay and cornmeal, molasses appeared to depress digestibility, somewhat, even when constituting only 11% of the dry matter.

224. Lindsey, J. B., and Smith, P. H., **Effect of Puerto Rico molasses on digestibility of hay and of hay and concentrates.** *Massachusetts Agr. Exp. Sta. Rpt.* 22:82-131. (1910).

Molasses exerted less depression of digestibility upon an all-hay ration than upon a concentrates-plus-hay ration. In the latter case the depression of digestibility averaged approximately 8%.

225. Mangold, E., **The suitability and digestibility of some new feeding stuffs containing urea.** *Forschungsdienst.* 3: 606-8. (1937); *C. A.* 32: 5039. (1938).

Beet pulp and molasses, among other things, were fed together with 15% urea to sheep. The urea appeared to be well utilized under these conditions.

226. Mills, R. C., Lardinois, C. C., Rupel, I. W., and Hart,

E. B., **Utilization of urea and growth of heifer calves with corn molasses and cane molasses as only readily available carbohydrate in the ration.** *J. Dairy Sci.* 27:571-8. (1944).

For maximum growth of calves, a ration made of roughage, molasses and urea must be supplemented with 3-5% of a more insoluble, but fermentable carbohydrate or insoluble protein which can be provided by cereal grains or concentrates such as oil meals.

227. *Nebraska Agr. Exp. Sta. Rpt.* 50:29; 51:39. (1937). **Molasses vs. corn for fattening yearling heifers.**

No detrimental effects or digestive disturbances have been noted from feeding large amounts (15 lbs. daily) of molasses.

228. Patterson, H. J., and Outwater, R., **The digestibility of molasses feeds.** *Maryland Agr. Exp. Sta. Bul.* 117:259-90. (1907).

These results show that the addition of molasses to a ration has a tendency to increase the digestibility of both hay and grain feeds. This, coupled with the generally observed fact that molasses contributes toward making feeds more palatable and also acts as an appetizer, gives to molasses a relatively high place as a stock food and makes it more valuable than its analysis alone would indicate. The authors comment, in studying the results that the protein is sometimes not so digestible in the presence of molasses, and that this suggests the thought that it may be that the presence of the readily available energy of the molasses has filled the requirements of the animal and thus not necessitated the breaking up of more difficult protein compounds."

229. Snell, M. G., **Blackstrap molasses and corn-soybean silage for fattening steers.** *Louisiana Agr. Exp. Sta. (Bien.) Rpt.* 1930/31. (1931); *Louisiana Agr. Exp. Sta. Bul.* 266:22. (1935).

The addition of molasses to a dry ration had no significant effect on the digestibility of any of the nutrients except NFE and ash which were increased. When the ration contained silage the addition of molasses reduced the utilization of nitrogen.

230. Voltz, W., **The value of the amide mixture from (beet) molasses for ruminants.** *Arch. ges. Physiol. (Pfluger).* 117:541-63. (1907); *C. A.* 1:1884. (1907).

Nitrogen balance investigations with adult sheep showed that the nitrogen of beet molasses was as well utilized as were proteins.

231. Voltz, W., Dietrich, W., and Deutschland, A., **The utilization of molasses amides in comparison with protein by the organisms of ruminants.** *Landw. Jahrb.* 52:431-55. (1918).

During the feeding of beet molasses, which is high in amide nitrogen, about 77% of the amides were digested and more true protein nitrogen appeared in the feces than was taken in the food in an experiment with a wether.

232. Williams, P. S., **The effect of cane molasses on the digestibility of a complete ration fed to dairy cows.** *J. Dairy Sci.* 8:94-104. (1925). *Pennsylvania Agr. Exp. Sta. Bul.* 188:17-8. (1924).

Using the same 4 Holstein cows, the basal ration was fed alone first, then plus 15% molasses, then plus 25% molasses. These treatments were repeated 3 times each. Each trial ran for 21 days. Molasses neither increased nor decreased the digestibility of fiber, NFE, ether extract, protein or dry matter significantly.

233. Zuntz, **Feeding of sugar-containing feed materials.** *Ztschr. Ver. Deut. Zuckerindus.* No.701. II:485-98. (1914); *Exp. Sta. Rec.* 32:767-8. (1915).

In respiration experiments with ruminants using molasses it was concluded that the carbohydrates of molasses have a higher nutritive value for horses and swine than for ruminants, because molasses undergoes fermentation in the rumen so readily.

## Molasses Grass and Legume Silages

234. Allen, L. A., Watson, S. J., and Ferguson, W. S., **The effect of the addition of various materials and bacterial cultures**

**to grass silage at the time of making, on the subsequent bacterial and chemical changes.** *J. Agr. Sci.* 27:294-308. (1937).

The addition of soluble carbohydrate (such as in molasses) appears to be beneficial by encouraging the formation of lactic acid which reduces the pH to a low value. The development of desirable flora may be further assured by inoculating the molasses with a suitable culture. A mixed culture of lactobacilli of the Streptobacterium plantarum type, found by experiment to ferment the carbohydrates in molasses, would be beneficial.

235. ALMGREN, K., **The making of herbage silage by addition of sugar by-products and salt.** *Kgl. Lantbruksakad. Tidskr.* **86,** No.4:298-307. (1947).

Batches of 200 lbs. of vetch, peas and green oats (60:25:15) were treated as follows: (1) 1.2% molasses; (2) 0.5% salt; (3) no treatment. The molasses (1) and the salt (2) gave excellent silages, pH 3.8 and 4.0 respectively. In a later study 2% cane molasses, 2% beet molasses, and 2% wood sugar molasses were compared. The cane and beet molasses gave excellent silages but the wood molasses did not. The pH was 4.6 with wood molasses. The negative control with no treatment spoiled completely, final pH 8.5.

236. ARCHIBALD, J. G., **Studies in the chemistry of grass silage.** *J. Agr. Res.* **72**:277-87. (1946).

A biochemical study of 40 samples of different kinds of silage stored with various preservatives. Of the preservatives used, molasses and ground wheat were by far the most effective. Salt, lactic acid cultures and urea were usually inferior to no preservative at all. Molasses tended to minimize the losses of nutrients during storage.

237. ARCHIBALD, J. G., BOHSTEDT, G., KNOTT, J. C., MONROE, C. F., WOODWARD, T. E., and BENDER, C. B., **Committee Report on silage methods, evaluations, etc. for the Amer. Dairy Sci. Assn. Presented at the East Lansing Meeting in June 1942.** *J. Dairy Sci.* **26**:213-5. (1943).

Standards established for reporting trials conducted on value of silage in livestock feeding.

238. Archibald, J. G., and Parson, C. H., **Grass silage.** *Massachusetts Agr. Exp. Sta. Bul.* 425:11. (1945).

Molasses was found to be a satisfactory preservative at 60 and 150 lbs. per ton. Urea, lactic acid cultures, salt, and a combination of lactics and salt were unsatisfactory.

239. Autrey, K. M., Knodt, C. B., and Williams, P. S., **Grass and legume silage studies using 2-quart glass jars as miniature silos.** *J. Dairy Sci.* 30:775-85. (1947).

Sixty lbs. molasses and 100 lbs. hominy feed were equally effective as preservatives under the conditions of the experiment. Fermentation in glass jars appeared to be similar to that which occurs in commercial silos.

240. Axelsson, J., and Eriksson, S., **Influence of adding AIV-acid, molasses, buttermilk and whey-powder in ensiling green crops.** *Kgl. Lantbruks-Hobskol. Ann.* 16:515-30. (1949).

Comparison in the laboratory of ensiling grasses, legumes and beet tops with A.I.V. acid, molasses, buttermilk, and whey. Molasses was best, but whey was nearly as good.

241. Babcock, C. J., and Haller, H. S., **Effect of some silages on the copper tolerance of pasteurized milk.** *J. Dairy Sci.* 26:563-70. (1943).

The feeding of molasses-silage, straight alfalfa silage, soybean or corn silage had no significant effect on the copper tolerance of the milk produced.

242. Bender, C. B., **Molasses silage produces unusual results in feeding.** *Cert. Milk.* 12:136-9. (1937).

A roughage ration for cows which contained a high proportion of good quality molasses silage was superior to corn silage in its ability to produce milk of high color and flavor.

243. Bender, C. B., **An extension program in grassland farming.** *J. Dairy Sci.* 21:135. (1938).

Program includes both intensive pasture management and molasses grass silage as fundamental parts. Molasses preservation of legumes and grasses is excellent crop insurance because it eliminates the haymaking losses in inclement weather. This method provides a better labor distribution and any dairy farmer who has a silo, silage and hay machinery can carry out the program successfully and with sound feeding economy.

244. Bender, C. B., **Use of molasses in grass silage preparation.** *Sugar Res. Found. Tech. Rpt. Ser. No.4* (1948).

A review. 116 references.

245. Bender, C. B., Bartlett, J. W., Tucker, H. H., and Mixner, J., **Molasses grass silage as the sole roughage diet for milk production and growth of dairy animals.** *J. Dairy Sci.* **20**:424-6. (1937).

It was concluded from the results that molasses grass silage will replace corn silage or hay in the ration of a dairy cow without influencing the production level of the cow to any marked extent.

246. Bender, C. B., and Bosshardt, D. K., **Grass silage: A critical review of the literature.** *J. Dairy Sci.* **22**:637-51. (1939).

114 references.

247. Bender, C. B., Bosshardt, D. K., and Garrett, O. F., **Some chemical changes occurring in molasses grass silage.** *J. Dairy Sci.* **24**:147-51. (1941).

Oats and field peas preserved with 100 lb. molasses per ton showed major changes during first week. Ammonia nitrogen content was negligible indicating that although there is protein-breakdown, the presence of fermentable carbohydrates suppresses ammonia formation.

248. Bender, C. B., Olmstead, R. H., Merrill, A. R., and Hamlin, F., **Legume and grass silage: A survey of methods and results on 380 Northeastern farms (Ten states cooperat-**

ing). *New Jersey Agr. Exp. Sta. Bul.* 643. (1938); reprinted as *New Hampshire Agr. Exp. Sta. Bul.* 305. (1938).

Molasses, phosphoric acid, the A.I.V. process, and no preservatives were used by 328, 34, 3, and 15 farms, respectively. The amount of molasses added to various kinds of ensilage ranged from 14 lbs. to 250 lbs. per ton. Such silage was fed primarily to dairy cattle, but some also was fed to beef cattle, horses, sheep, swine and poultry. Best preservation of various silages was obtained with the following amounts of molasses per ton: grasses or cereals, 40; mixed grasses and legumes, 60; alfalfa or clovers, 80; and soybean, 100.

249. Bender, C. B., Tucker, H. H., Kreuger, W. C., Pfau, K. O., and Fox, A. S., **Molasses hay silage.** *J. Dairy Sci.* 19:137-46. (1936).

Ensiling of green grasses and legumes of high moisture content with 40 lbs. of molasses per ton will produce a good palatable silage. The ensiling of partially dried grasses or legumes (low moisture) resulted in moldy and charred silage unfit for feeding. The ensiling of high moisture grasses and legumes with molasses results in a very small loss in nutrients.

250. Bohstedt, G., Rupel, I. W., King, W. A., Peterson, W. H., and Hegsted, D. M., **Palatability and nutritive value of A.I.V. and molasses-alfalfa silage for dairy cows.** *Proc. Am. Soc. Animal Production* 1937:51-4. (1937).

No significant differences were found in palatability of the two silages. Carotene content of the milk from cows fed A.I.V.-alfalfa silage was higher than from those fed molasses-alfalfa silage.

251. Brenes, L. R., Marchan, F., and Del Toro, E., *J. Agr. Univ. of Puerto Rico.* 31:168-79. (1947).

Molasses, used up to 10% as a preservative for Meeker grass gave good color, odor, palatability and acidity. The pH of the silages ranged from 3.6 to 4.3.

252. Brosemer, L. J., **Use your silo all the time.** *Breeder's Gazette.* 103:6-7, 12. (1938).

Instructions to farmers concerning the use of molasses as a preservative for silages with testimonials as to the value of silage prepared in this way.

253. Brown, W. O., and Heaney, I. H., **The conservation of grassland herbage in lined trench silos. A comparison of nutrient losses and of feeding value in molassed and ordinary silages.** *J. Brit. Grassland Soc.* **6**:91-8. (1951).

Ordinary and molassed grass silages were put down in two concrete-lined silos and covered with 6 inches of soil but not roofed. The composition of the two silages was similar. Digestibility trials with sheep showed the ordinary silages to have lower, though similar, digestion coefficients.

254. Camburn, O. M., Ellenberger, H. B., Jones, C. H., and Crooks, G. C., **The conservation of alfalfa and timothy nutrients as silages and as hays.** III. *Vermont Agr. Exp. Sta. Bul.* **509**:32. (1944).

The TDNs and digestible protein recovered in the edible portions of a variety of silages using different preservatives was determined. Alfalfa, ensiled with 35% dry matter and preserved with 10% molasses showed the greatest recovery; 48.8 lbs. of TDNs per 100 lbs. of dry matter ensiled.

255. Camburn, O. M., Ellenberger, H. B., Newlander, J. A., and Jones, C. H., **Legume and grass silage.** *Vermont Agr. Exp. Sta. Bul.* **434**:18. (1938).

The addition of 2% of molasses to ensiled timothy and of 3 to 4% to ensiled alfalfa tends to induce fermentation and to decrease the liklihood of spoilage due to the presence of too much or too little moisture. The odor and palatability of such silages are enhanced when molasses is used.

256. Casalis, C. E. M., **Molasses silage process.** *Hoard's Dairyman.* **79**:140, 142. (1934).

Forty lbs. of molasses, diluted for ease of handling, was added per ton of alfalfa, cowpeas, oat grass, and several other grasses

and each was ensiled to test the molasses process. In both tower and pit silos, lined or unlined, there was practically no loss of nutrients as determined by chemical analysis and by feeding trials. The process is best for preservation of protein-rich crops. Molasses, during fermentation, favors a lactic acid type flora which suppresses organisms which break down proteins.

257. Churchill, B. R., **Results of alfalfa-grass-molasses silage experiments at the Upper Peninsula Experiment Station.** *Michigan Agr. Exp. Sta. Quart. Bul.* 22, No. 3:193-9. (1940).

The moisture content of hay to be ensiled should be approximately 60-70% and the use of molasses is recommended. Both protein and carotene were preserved better in silage than in sun-cured hay.

258. Churchill, B. R., and Horwood, R. E., **Methods of making and feeding alfalfa molasses silage.** *J. Dairy Sci.* 21:105-6. (1938).

Fifty tons of alfalfa molasses silage was made using 1.5% molasses. The silage was very satisfactory. Later 12 lots of silage were made, varying the molasses from none to 3%. Lots also varied as to stage of cutting and moisture content. Results of feeding trials are to be described elsewhere.

259. Coke, J. E., and Jones, R. D., **Method of reducing storage loss in siloed beet pulp.** *Proc. Am. Soc. Sugar Beet Technol.* 4:117-20. (1946).

Cane molasses (2.5—7.5%) and enough acid (HCl or $H_2SO_4$) to give a pH of 3.5, substantially reduced loss of dry matter and total nutrients over a 200-day period. Untreated siloed beet pulp lost 51.88% dry matter; that treated with 2.5% molasses lost 32.46%; with 5% molasses, loss was 18.65%; and with 7.5% molasses, loss was 25.86%. The loss due to acid treatment was 20.41%. Nutrient loss was slightly greater than solids loss.

260. Davies, W. M., Botham, G. H., and Thompson, W. B., **Grass silage. A comparison of the changes involved in the ordinary, molasses and A.I.V. processes.** *J. Agr. Sci.* 27:151-61. (1937).

All three products were equally palatable to cattle, but the A.I.V. was not palatable to sheep. Upon being taken from the silo, ordinary silage rapidly developed moulds. Not so with molasses and A.I.V. silages. There was improved conservation of proteins in the A.I.V. and of carbohydrates in the molasses processes. Molasses silage showed lowest losses of dry matter, the ordinary the highest and A.I.V. intermediate. The authors concluded that "There appears every reason to encourage the use of molasses."

261. DIJKSTRA, N. D., **Investigations in silage-making by means of a "press-silo of the Schmidt system."** *Versl. landbouwk. onderz.* **No. 51** (1) :40. (1945).

A "press-silo" in which the silage was kept under pressure by means of a moveable cap capable of being pressed down by screws was found to produce no better molasses-grass silage than was produced in a similar water-tight silo by merely compressing the silage with a layer of soil.

262. DIJKSTRA, N. D., **Comparative experiments on silage-making in a water-tight and in a drained silo.** *Versl. landbouwk. onderz.* **No. 57.** 11 :16. (1951).

When wet grass was ensiled with molasses in a drained silo, nearly 20% of the added molasses was lost in the effluent. Consequently, in a water-tight silo the amount of molasses could be reduced by 20%. In the water-tight silo, the juices could be gathered and fed to the cattle, thereby reducing loss of nutrients contained therein.

263. DIJKSTRA, N. D., **Use of chemicals in the preservation of grass and other crops (as silage) in the Netherlands.** *Proc. 11th intern. congr. pure applied chem. London.* 3 :63-9. (1947, published 1951).

The pros and cons of almost every known method of silage preservation are discussed. A preservative should: (1) prevent butyric acid production, (2) improve palatability, (3) keep nutrient loss at a minimum and (4) be economical to use. Of all methods, the use of molasses at approximately 4% in water-tight silos or 6% in drained silos appeared to be the most satisfactory.

264. Duffee, F. W., **Applying molasses to forage for silage.** *Hoard's Dairyman.* **83**:261. (1938).

Detailed instructions on the methods of adding molasses during the preparation of silage.

265. Elting, E. C., **Molasses as a preserving agent in making soybean silage.** *J. Dairy Sci.* **18**:440. (1935).

One per cent molasses diluted with an equal amount of water was added to immature soybeans. Dry matter content was 21.25%. Ten weeks later the silage was found to be excellent. Clean acid odor, dark green color and no evidence of putrefaction. In tests with milking cows it was found to be very palatable and did not impart any objectionable flavors or odors to the milk. There was a 15% loss of protein as compared to fresh soybeans. Heavy milking cows remained in positive Ca and P balance while consuming silage.

266. Elting, E. C., and LaMaster, J. P., **Molasses as a preserving agent in making soybean silage.** *Proc. Assoc. Southern Agr. Workers.* **36.** (1935).

For abstract see No. 265.

267. Forbes, E. B., Bratzler, J. W., and French, C. E., **Utilization of certain feeding stuffs by cattle.** *Pennsylvania Agr. Exp. Sta. Bul.* **391**:14. (1940).

The digestibility of 3 molasses silages was in each case materially higher than was the digestibility of the phosphoric acid silage made from the same plant material, with respect to NFE and energy; and in 2 out of 3 trials, with respect to crude fiber and ether extract. Nitrogen digestibility was higher, in each test on the phosphoric acid silage.

268. Garrett, O. F., Hartman, G. H., and Arnold, R. B., **Some factors affecting the stability of certain milk properties. I. Effect of succulent roughages on flavor.** *J. Dairy Sci.* **22**:717-27. (1939).

Molasses grass silage was superior to either beet pulp or corn

silage in producing (1) superior initial milk flavor, (2) more stable milk flavor in storage and (3) a milk more stable toward catalytic effects of added Cu.

269. Garrett, O. F., Arnold, R. B., and Hartman, G. H., **Some factors affecting the stability of certain milk properties. II. Effect of succulent roughages and of storage conditions on color.** *J. Dairy Sci.* 22:813-20. (1939).

The yellow color of the milk produced on molasses grass silage is more stable in storage than is that of milk produced on either beet pulp or corn silage.

270. Garrett, O. F., Arnold, R. B., and Hartman, G. H., **Some factors affecting the stability of certain milk properties. IV. A comparison of seven different roughages on the color and flavor of milk.** *J. Dairy Sci.* 24:71-83. (1941).

Alfalfa-molasses silage was almost equal to spring pasture in putting yellow color into milk and was equal to or better than spring pasture in producing milk of fine flavor and resistance to development of oxidized flavor. The differences between molasses and phosphoric acid silages in these respects were not considered significant.

271. Garrett, O. F., Bender, C. B., and Tucker, H. H., **Relation of grass silage to the color, vitamin C and flavor in milk from individual cows.** *J. Dairy Sci.* 20:426-7. (1937).

Comparing molasses-mixed grasses silage with corn silage and mixtures of grass silage and hay and corn silage and hay using both Guernsey and Holstein cows it was concluded that the molasses-grass silage as part or all of the roughage promoted the best milk color and flavor. Also vitamin C was higher in these groups and tended to correlate with good color and flavor.

272. Garrett, O. F., and Bosshardt, D. K., **Effect of feeding silages on certain properties of milk.** *New Jersey Agr. Exp. Sta. Bul.* 710:30. (1944).

Alfalfa silage, whether preserved with molasses or with phosphoric acid, is capable of producing a milk with higher yellow color,

better flavor and greater resistance to development of oxidized flavor than that produced with corn silage, green oat silage or soybean silage.

273. Hathaway, I. L., Davis, H. P., and Brauer, J. C., **The vitamin A content of A.I.V., molasses and normal silage and the effect of feeding these silages upon the vitamin A content of the milk.** *J. Dairy Sci.* **19**:452. (1936); *Nebraska Agr. Exp. Sta. Res. Bul.* **101**:14. (1938).

Normal silage was decidedly inferior in vitamin A content to molasses and A.I.V. silage which were approximately equivalent. Vitamin A content of the milk was correlated with that in the silages. Full feeding of alfalfa hay promoted a higher level of vitamin A in the milk than any of the silages.

274. Hayden, C. C., Perkins, A. E., Monroe, C. F., Krauss, W. E., Knoop, C. E., and Washburn, R. G., **Molasses treatment for meadow-crop silage.** *Ohio Agr. Exp. Sta. Bimonthly Bul.* **234**: 102-8. (1945).

Using levels of molasses ranging from 40 to 100 lbs. per ton of silage, results were obtained indicating that 40 lbs. of molasses per ton is as satisfactory as higher amounts.

275. Hayden, C. C., Perkins, A. E., Monroe, C. F., Krauss, W. E., Washburn, R. G., and Knoop, C. E., **Hay crop silage. A summary of ten years' work.** *Ohio Agr. Exp. Sta. Bul.* **656**:24 (1945).

Molasses-treated silages were better than silages preserved by other methods. Molasses was added at from 33 to 100 lb. per ton of green crop. Carotene retention was better and palatability somewhat better in molasses-treated silages.

276. Hegsted, D. M., and Bohstedt, G., **Effect of molasses and A.I.V. silages on the carotene and vitamin A content and the growth-promoting quality of milk.** *J. Dairy Sci.* **20**: 430-1. (1937).

Blackstrap molasses at 100 lbs. per ton and 65 lbs. per ton was

added to green alfalfa for ensiling. In feeding trials with cows over three-month periods in two sucessive years showed both silages to cause milk production and weight maintenance equivalent to that obtained with alfalfa hay. Carotene and vitamin A values for the milk showed no significant differences. Milk from all groups also supported uniform growth in rats.

277. Hegsted, D. M., Quackenbush, F. W., Peterson, W. H., Bohstedt, G., Rupel, I. W., and King, W. A., **A comparison of alfalfa silages prepared by the A.I.V. and molasses methods.** *J. Dairy Sci.* 22:489-500. (1939).

Alfalfa silages preserved by molasses and A.I.V. methods were compared over a 3-year period. Best preservation occurred when dry matter was 20-25% or below. There were no pronounced chemical differences, although protein and carotene were slightly higher in the A.I.V. silage. Both silages were equally satisfactory for milk production, the milks being equally satisfactory for the growth of rats. In tests during one year, none of the milks supported growth in guinea pigs. On the basis of these tests and conditions of farm practice, molasses silage was recommended over A.I.V.-silage.

278. Hellberg, A., *Biedermanns Zentr. B. Tierernahr.* 14: 375-416. (1942).

A.I.V. (HCl plus $H_2SO_4$), "Amasil" (90% $HCO_2H$), red Penthesta (98% $SO_3$, 2% $H_3PO_4$) and molasses were compared as silage preservatives with grass, clover and alfalfa. A.I.V. method gave lowest loss of dry matter. No differences in quality of silages produced by all methods.

279. Herman, H. A., Ragsdale, A. C., and Heathman, W., **Trench silos for preserving cereals treated with molasses or phosphoric acid.** *J. Dairy Sci.* 24:514-5. (1941).

The trials indicated that trench silos may be used for ensiling chopped cereals, such as barley, treated with either molasses or phosphoric acid. The resulting silage will be palatable and satisfactory for milk production. Molasses silage caused one pound more milk per cow per day than phosphoric acid silage, but this difference was not considered significant.

280. Hill, J. A., **Comparison of carotene content of molasses-treated alfalfa silage and salt-treated alfalfa silage.** *Wyoming Agr. Exp. Sta. Rpt.* 1946/47:2-61. (1947).

Molasses-treated silage had much more carotene than salt-treated silage as determined chemically. These findings were reflected in the results obtained when the two silages were fed to lambs, the salt-treated silage giving much poorer gains.

281. Horner, B. K., **Legume and grass molasses silage.** *Rural New Yorker.* 98:40, 352. (1939).

Nine advantages are listed in the use of legume and grass molasses silage: (1) No waiting on weather; (2) no damaged hay; (3) no work in hot, dusty hay-mow; (4) saving in storage space; (5) big reduction in fire hazard; (6) less work at feeding time; (7) cleaner stables and cleaner milk; (8) eliminates feed wastage; (9) more growth and milk on less acreage.

282. Horwood, R. E., **Alfalfa-molasses silage vs. alfalfa hay as a roughage for lactating dairy cows.** *J. Dairy Sci.* 19: 520-1. (1936); *Michigan Agr. Exp. Sta. Quart. Bul.* 19:100-4. (1936).

Chopped alfalfa preserved with 30 lbs. molasses plus water per ton was compared with unchopped alfalfa hay plus molasses. The latter was even more palatable than the former. In comparing alfalfa silage with alfalfa hay as roughage it was found that the silage ration produced 10,484 lbs. of 4% fat-corrected milk while the hay ration produced 10,173 lbs. Cows on silage gained 178 lbs. in weight, cows on hay gained 224 lbs. in weight. Cows on hay consumed slightly more grain.

283. Hunter, O. W., **Bacteriological studies on alfalfa silage.** *J. Agr. Res.* 15:571-92. (1918).

Although silage made from alfalfa plus molasses was vastly superior to that made from alfalfa alone, the microbial flora of the two types of silage, so far as noted, were practically identical.

284. Jarl, F., *Lantbruksbogskol. Husdjursforsoksenstalt. medd. No.* 32:96. (1948).

Comparisons were made between A.I.V. acid (a mixture of HCl and $H_2SO_4$), molasses at 1, 2 and 3% molasses plus lactic acid bacteria as preservative for silage. Molasses at 1, 2 and 3% gave best results. Greatest loss of protein occurred with A.I.V. method. It was 14.5% higher loss than with molasses. Lactic acid bacteria did not have much effect on pH or other criteria.

285. Johnson, B. C., Peterson, W. H., Hegsted, D. M., and Bohstedt, G., **A study of various methods of preserving legumes and other forages by ensiling.** *J. Agr. Res.* 62:337-48. (1941).

Over 100 lots of silage put up in many ways over a period of several years were compared as to appearance, odor, preservation, pH value and carotene content. The A.I.V. and $H_3PO_4$ procedures gave generally good results. Three per cent molasses was best for alfalfa and 5% molasses was best for soybeans. No differences between cane and beet nor between diluted and non-diluted molasses. All gave uniformly good results. Of the following preservatives: whey powder, soured-whey concentrate, corn meal, sulfamic acid, soured molasses, NaCl and phosphorus pentasulfide; whey powder, soured whey concentrate and corn meal gave best results.

286. Johnson, B. C., Peterson, W. H., King, W. A., and Bohstedt, G., **Alfalfa silage preservation. Comparison of phosphoric acid and molasses as preservatives.** *Ind. Eng. Chem.* 32: 1622-5. (1940).

Chemical studies showed no pronounced differences between phosphoric acid silage (20-30 lbs. per ton) and molasses silage (65 lbs. per ton), but showed poorer preservation and greater loss of carotene with lower amounts of phosphoric acid. Both were equally satisfactory as to palatability, milk production and milk flavor. The carotene and vitamin A content of the silage-produced milk were high as compared to averages for Wisconsin winter market milk.

287. King., W. A., **Balance studies on milking cows fed molasses grass silages and phosphoric acid grass silages.** *J. Dairy Sci.* 26:732-3. (1943).

Retention of N, Ca, and P was better with the molasses-alfalfa and molasses-oat silages than with corresponding silages treated with $H_3PO_4$.

288. King, W. A., **The value of molasses and $H_3PO_4$-alfalfa silages in the rations of dairy cows.** *New Jersey Agr. Exp. Sta. Bul.* **704**:35. (1943).

For abstract see No. 293.

289. King, W. A., **Comparison of molasses-oat silage and phosphoric acid-oat silage as feeds for the milking cow.** *New Jersey Agr. Exp. Sta. Bul.* **708**:22. (1944).

Molasses-oat silage proved to be superior to phosphoric acid-oat silage. The molasses silage promoted better phosphorus retention, was more palatable, improved economy of milk production and lessened physiological disturbances.

290. King, W. A., **Comparison of molasses-soybean silage and corn meal-soybean silage as feeds for the milking cow.** *New Jersey Agr. Exp. Sta. Bul.* **713**:20. (1944).

Cornmeal-soybean silage appeared to be more palatable than molasses-soybean silage. Otherwise, when fed with hay and grain, they were quite comparable.

291. King, W. A., **Comparison of molasses-grass silage and ground barley-grass silage as feeds for the milking cow.** *New Jersey Agr. Exp. Sta. Bul.* **722**:18. (1945).

The TDNs and metabolizable energy of ground barley-grass silage were higher than those of molasses-grass silage, but not as much higher as might have been expected. Both silages, with hay, led to retention of N, Ca and P in milking cows.

292. King, W. A., **Comparison of molasses-timothy silage and ground barley-timothy silage as feeds for the milking cow.** *New Jersey Agr. Exp. Sta. Bul.* **723**:17. (1945).

On a dry matter basis, corn silage contained more nutrients than

molasses-timothy silage and barley-timothy silage, but in economy of milk production in terms of 4% fat-corrected milk per lb. of TDNs, corn silage and molasses-timothy silage were equivalent while barley-timothy silage was significantly lower.

293. King, W. A., Patrias, G. C., and Russell, W. C., **The value of molasses and phosphoric acid-alfalfa silages in the rations of dairy cows.** *J. Animal Sci.* 1:67-8. (1942).

Molasses-alfalfa and $H_3PO_4$-alfalfa silages were each fed to 3 cows. Similar studies were made on 2 additional groups of cows fed these supplements with hay and grain. All cows were in positive nitrogen balance by as much as 20 gm. per day. With exception of one period, all Ca and P values were negative with cows fed the $H_3PO_4$-alfalfa silage even when 150 gms. limestone per day was fed to neutralize one hydrogen ion in the acid. On the other hand, all Ca and P balances were positive, with the exception of one cow, when molasses-alfalfa silage was fed, in spite of a much lower P intake. Only slight differences were observed in over-all digestibility between the two silages.

294. Kutish, L. J., **Molasses for silo feed.** *Flour & Feed.* **51,** No.5:24. (1950).

A discussion of the value of molasses in preserving silage.

295. Kutish, L. J., **Molasses with silage.** *Flour & Feed.* **51,** No. 6:26. (1950).

A further discussion of the use of molasses in making silage.

296. Lepard, O. L., and Savage, E. S., **The feeding value of grass silage in the ration for dairy cows.** *J. Dairy Sci.* **24:** 549-60. (1941).

In comparing molasses silages of grass, clover and alfalfa with corn silage and dry hay in three groups of cows over a 15-week period, no significant difference in production was noted provided the TDN intake remained constant. Molasses silages and phosphoric acid silages were found to be approximately equivalent.

297. McAuliffe, H. D., Stone, R. W., and Bechdel, S. I., **Fermentation studies on alfalfa silage prepared by the phosphoric a cid and molasses methods.** *J. Dairy Sci.* 23:561. (1940).

Different sections of the molasses-alfalfa silage in a silo may have different bacterial action if the molasses is not mixed uniformly throughout and if different pressures exist within the silo.

298. Murray, C. A., Romyn, A. E., and Fitt, R. H., **Cowpea molasses silage for fattening steers.** *Rhodesia Agr. J.* 34:201-70. (1937).

Adding molasses during preparation of cowpea silage makes it keep and aids very much in its palatability. Three pounds of the silage replaced one pound of cowpea hay in a mixed ration.

299. Nevens, W. B., Harshbarger, K. E., and Kendall, K. A., *Illinois Agr. Exp. Sta. Bul.* 529:3-26. (1948).

Molasses improved silages of various types: alfalfa, soybean, immature Indian grass, brome grass, broom corn, oats, sorghum. All were well preserved and made more palatable by using molasses. On the other hand, ammonium carbonate, urea, sodium sulfate, lactic acid cultures and ground corn cobs were not effective silage preservatives.

300. Nevens, W. B., and Kuhlman, A. F., **Alfalfa silage.** *J. Dairy Sci.* 19:611-7. (1936).

Blackstrap cane feeding molasses incorporated with alfalfa at time of ensiling caused desirable acid condition as compared to no molasses.

301. Newlander, J. A., Ellenberger, H. B., Camburn, O. M., and Jones, C. H., **Conservation of alfalfa, timothy and soybean nutrients as silages and as hays.** *Vermont Agr. Exp. Sta. Bul.* 459:42. (1940).

Although it was found possible, under rigidly controlled conditions, to ensile legumes without a preservative, the use of molasses

or mineral acids gave greater assurance of obtaining good silage under New England conditions.

302. Odland, T. E., Cox, T. R., and Smith, J. B., **A comparison of different crops for grass silage by the use of mason jars as miniature silos.** *J. Am. Soc. Agron.* 33:304-13. (1941).

Clover, alfalfa, soybeans, millet, sudan grass, rye, timothy and Kentucky blue-grass all made good silages with either molasses or phosphoric acid, provided the moisture content and stage of maturity were near optimum.

303. Pratt, A. D., **Peppergrass silage.** *J. Dairy Sci.* 27: 365-7. (1944).

Ensiling peppergrass with molasses produced a palatable silage which, after fermentation had no peppergrass flavor. Neither cream nor butter production from cows receiving the silage had any off-flavors. Peppergrass seeds failed to germinate after being ensiled for only 2 weeks.

304. Pratt, A. D., and Holdaway, C. W., **The feeding value of clover-molasses silage for milking cows.** *Virginia Agr. Exp. Sta. Bul.* 353:15. (1943).

Molasses was preferable to mineral acids as the preservative for clover silage.

305. Reed, O. E., and Fitch, J. B., **Alfalfa silage.** *Kansas Agr. Exp. Sta. Bul.* 217. (1917).

Data are given for the percentages of sugar and lactic acid at different stages after ensiling alfalfa alone and mixed with molasses, 20:1 and 10:1. Addition of a carbohydrate to silages resulted in improved preservation of the silage. Blackstrap molasses proved to be the best preservative of all those examined.

306. Savage, E. S., **Molasses silage.** *Flour & Feed.* 38, No.1:18. (1937).

A Cornell experiment on making molasses hay silage is dis-

cussed. Forty lbs. of molasses per ton of grass and legume silage appeared to be an insufficient amount. Also, it appeared that the total moisture content in order to make good silage should be about 65% of the mass.

307. Schieblich, M., **The influence of water content and the addition of various large quantities of sugar on the process of silage fermentation.** *Biedermann's Zentr., B. Tierernahr.* **3**:437-49. (1931); C .A. **26**:1360. 1932.

It was possible to produce an excellent silage by first drying the alfalfa to a moisture content of 65%. With a water content of 79% (normal) or 85% good silage was not obtained unless 1% of cane sugar was added.

308. *Sci. Rep. Imp. Inst. Agr. Res., Pusa.* **1932/33.** (1934); **1933/34**:126. (1936).

In the conservation of fodder and grasses, great advantage results from the use of molasses in silage.

309. Swanson, C. O., and Tague, E. L., **Chemical studies in making alfalfa silage.** *J. Agr. Res.* **10**:275-92. (1917).

Molasses was the most effective supplement for use as a preservative, in making alfalfa silage as compared to germinated and sound corn, rye and tightly sealed silos without a preservative. The molasses sugar disappears rapidly with the formation of acids. Properly preserved silage contains no sugar after the first few weeks. (Note—This appears to be the first paper on use of molasses as preservative)

310. Ullmann, G., **Straw molasses for silage.** *Flour & Feed.* **52**, No.5:24. (1951).

Dr. Ullmann of London, writing in Review of Industry from which the present article was taken, suggests that straw molasses, prepared by the action of sulfuric acid on straw followed by neutralization of the acid with lime, would possibly be suitable for making silage and if so, neutralization might not be necessary.

311. Watson, S. J., and Ferguson, W. S., **The value of artificially dried grass, silage made with added molasses and A.I.V. fodder in the diet of the dairy cow and their effect on the quality of the milk, with special reference to the value of the non-protein-nitrogen (NPN).** *J. Agr. Sci.* 26:337-67. (1936).

Artificially dried grass, molasses silage and A.I.V. fodder were found to give equally good quality, palatable and highly digestible feeds. Even though part of the protein in the silages was broken down to NPN, it appeared to be none-the-less digestible by the animals.

312. Watson, S. J., and Ferguson, W. S., **The chemical composition of grass silage.** *J. Agr. Sci.* 27:1-41. (1937).

Both molasses and A.I.V. reduced the formation of volatile bases-(ammonia) as compared to ordinary silage. Changes in acids, volatile and non-volatile, were of the type which makes for better preservation in the molasses and A.I.V. silages than in the control. As a result of these tests the authors conclude that molasses or acid should be added in order to be assured of first-class silage.

313. Watson, S. J., and Ferguson, W. S., **The losses of dry matter and digestible nutrients in low-temperature silage, with and without added molasses or mineral acids.** *J. Agr. Sci.* 27: 67-107. (1937).

Although A.I.V. method gives silage with lowest losses, the advantage over the molasses process is not sufficient to justify the general application of the former.

314. Waugh, R. K., Hauge, S. M., Wilbur, J. W., and Hilton, J. H., **A comparison of alfalfa-brome grass silage and corn silage for dairy cows.** *J. Dairy Sci.* 26:921-7. (1943).

When preserved with 80 lbs. of blackstrap molasses per ton of green material, alfalfa-brome grass silage was found to be slightly better than corn silage. Carotene content of the silage and of the blood plasma and butterfat produced were higher in the case of the alfalfa-brome-molasses silage.

315. Wilson, J. K., and Webb, H. J., **Water soluble carbohydrates in forage crops and their relation to the production of silage.** *J. Dairy Sci.* 20:247-63. (1937).

A number of silage-making trials are reported in which various grasses and legumes were ensiled with the addition of fermentable sugar such as that in molasses. It was shown that this method, as with the addition of mixtures of organic and mineral acids, produced superior silages.

316. Winters, S. R., **A possible reduction in ratio of molasses to alfalfa for silage preservation.** *Guernsey Breeder's J.* 59:774-5. (1941).

An article pointing out that the amount of molasses usually used in ensiling alfalfa can be reduced for sake of economy, without injuring the silage.

317. Woodward, T. E., **Methods of making grass silage.** *J. Dairy Sci.* 19:460. (1936).

A single trial with the addition of molasses failed to disclose the advantage in using molasses.

318. Woodward, T. E., **The viability of seeds as affected by the siloing process.** *J. Dairy Sci.* 23:267-71. (1940).

Silages of corn, grass and alfalfa, with or without added molasses, all destroyed the viability of most of the weed seeds deliberately ensiled with the silages. There was only slight loss in germination in comparable seeds held in bottles at room temperature as controls. The conversion of weedy crops into silage instead of hay should help in the control of weeds.

319. Ziegler, P. T., Bentley, F. L., and Miller, R. C., **Alfalfa-molasses silage as a roughage in steer fattening.** *Pennsylvania Agr. Exp. Sta. Bul.* 507:20. (1949); 410:13. (1941); 429:14. (1942).

The results of three steer feeding trials indicated that alfalfa-molasses silage as the main roughage was slightly superior to alfalfa

hay of No. 3 grade, made under June weather conditions in Pennsylvania, but had no advantage over corn silage.

## MOLASSES FOR HORSES AND MULES

320. Alquier, J., **Influence of foods containing sugar upon the digestibility of rations of horses.** *Cong. Internat. Aliment. Ration. Betail, Rap.* **1905**:1-12. (1905).

Molasses was found to decrease digestibility which was explained by the laxative properties of the alkaline salts contained in the beet molasses.

321. Berns, G. H., **Molasses as a food for horses.** *Am. Vet. Rev.* **26**:23. (1902).

A discussion of recent experiments on the value of molasses as a food for horses with some additional experimental work showing that "molasses-fed horses will do fully as much work and at the same time remain as a rule in better general condition than animals on dry food, while the cost of feeding is reduced from 25 to 33%."

322. Dalrymple, W. H., **The feeding of molasses to work stock.** *Louisiana Planter.* **34,** No.19:302-4; No.20:319-21,323. (1905); *Breeder's Gaz.* **48,** No.6:231; No.7:276-7; No.8:325-6; No.15:697. (1905).

On the basis of data gathered from a large number of Louisiana planters, the author states that molasses is used on an average consumption on 42 plantations at the rate of 9.5 lbs. per head per day, and that all animals have been maintained in good health under this regime. Examples of rations which go well with molasses are given, chopped hay, peavine, or alfalfa, and some concenterated feed are commonly mixed with the molasses and the whole fed in 3 portions. It is desirable to begin with smaller quantities of molasses and increase the level gradually.

323. Dalrymple, W. H., **Our available stock foods.** *Louisiana Agr. Exp. Sta. Bul.* **86**:24. (1905).

In a survey of Louisiana planters it was judged that molasses effected a saving of 10 to 50% in feed bills, diminished the number of cas es of "dietetic ailments" such as colic, etc. and improved the health of horses and mules.

324. GRANDEAU, L., **The use of molasses in feeding horses.** *J. agr. prat.* **61**, No.14:489-91. (1897).

The author quotes the work of other investigators and points out the value of molasses as a part of the ration for horses.

325. GRIFFIN, G. E., **Molasses as a food for army horses.** *Twentieth Century Farmer.* No. 69:2. (1902).

The author concludes from his tests that 35 lbs. of grass hay and 13 to 15 lbs. of molasses daily per 1000 lbs. live weight is sufficient to maintain a horse in good working condition in a climate like that of Puerto Rico.

326. HITIER, H., **The feeding of farm animals with molasses at Noyelles-sur-Escant.** *J. agr. prat.* **N. Ser. 8**:302-4. (1904).

The successful feeding of molasses as a part of the rations for horses and draft oxen is described.

327. OGILVY, L., **Sustaining horses in long distance travel.** *Breeder's Gaz.* **56**:1292-4. (1909).

An account is given of the methods of feeding employed in tests of long-distance riding. The advantages of feeding both sugar and molasses are pointed out.

328. SNELL, M. G., and TAGGART, W. G., **Molasses for work mules.** *Louisiana Agr. Exp. Sta. Bien. Rpt.* **1928/29**:30. (1929); *Louisiana Agr. Exp. Sta. Bul.* **230**:16. (1932).

The work indicated that molasses as the sole concentrate was not adequate for work mules. A combination of blackstrap molasses, corn and alfalfa or soybean hay, made an excellent ration for work mules. Molasses was equal to corn in feeding value and, up to

9 lbs. per head daily, could be fed in this type of mixture with satisfactory results.

329. Snell, M. G., and Taggart, W. G., **Blackstrap molasses for farm work mules.** *Proc. Am. Soc. Animal Production.* 1931:192-5. (1932).

One mule of each of 7 teams received molasses as replacement for part of the corn, alfalfa hay and soybean hay ration. Equivalent results were obtained. Nine lbs. appeared to be maximum per day. Heavy molasses feeding seemed to increase sweating and "winding" of mules. Molasses appeared to increase apptetite for other feeds.

330. Snell, M. G., and Taggart, W. G., **Blackstrap molasses as a feed for Louisiana work mules.** *Proc. Am. Soc. Animal Production.* 1932:110-12. (1933).

Molasses can be substituted for corn up to a level of 9 lbs. per day in a mule's ration containing gound corn and shuck (alfalfa hay and soybean hay).

331. Snell, M. G., Upp, C. W., and Lush, R. H., **Blackstrap molasses as a livestock feed.** *Louisiana Agr. Exp. Sta. Circ.* 19: 1-2. (1937).

The following conclusions were drawn from studies on molasses for mules: (1) Molasses is equivalent to corn as a feed for farm work mules. (2) Molasses increases the appetite of mules for other feeds. (3) Nine lbs. per day is maximum amount of molasses for a 1250 lb. farm work mule. (4) Heavy feeding of molasses during hot summer months seems to increase the sweating and "winding" of mules.

In a study on molasses for beef cattle 3 lots of steers were fed fattening rations for 112 days. Lot (1) received 13.25 lbs. shelled corn per day; Lot (2) received 3.31 lbs. molasses and 9.94 lbs. corn; Lot (3) received 6.62 lbs. molasses and 6.62 lbs. corn. Each lot also received 2.5 lbs. cottonseed meal, 6 lbs. cottonseed hulls and 0.12 lbs. minerals per day per steer. Molasses had 88% of the feeding value of corn in Lot (2) and 74% in Lot (3). Addition of molasses tends to make other feeds, such as low grade hays more palatable for steers.

332. Trowbridge, E. A., Moffett, H. C., **Molasses in ration for horses.** *Missouri Agr. Exp. Sta. Bul.* 370:16. (1936).

A group of horses receiving 6 to 8 lbs. of molasses per day as a substitute for part of the grain, performed as satisfactorily as horses receiving the control ration.

333. Walton, T. H., **Economic feeding of working horses.** *Agr. Gaz. New South Wales.* 9:169-72. (1898).

A mixture of 15 lbs. of Fiji cane molasses plus 3 lbs. of bran and 4 lbs. of corn was found to be superior to an all-grain ration for 1,270 lb. working horses. In addition, green cane tops were fed. Molasses did not cause diarrhea, but rather constipation, which was counteracted by feeding the bran. Molasses produced no undue fattening softness, nor injury to the wind.

## MOLASSES IN THE FEEDING OF SWINE

334. Aubel, C. E., **Swine feeding investigation, 1936 to 1940.** *Kansas Agr. Exp. Sta. Circ.* 207:20. (1941).

Substitution of blackstrap molasses for corn at levels of 11.5, 20.3 and 29.4% of the ration did not prove very satisfactory. One hundred lbs. of molasses appeared to replace 7 lbs., 18.1 lbs., and 27.1 lbs. of corn at the respective levels of feeding.

335. Barnett, E., and Goodell, C. J., **Grazing and feeding trials with hogs.** *Mississippi Agr. Exp. Sta. Bul.* 218:32. (1923).

An experiment was conducted using 3 lots of 5 hogs each averaging 160 lbs. in weight. The basal ration consisted of corn, wheat-shorts and tankage, (5:5:1). Lot (1) received basal diet only, Lot (2) received 3 parts of blackstrap molasses in place of 2 parts of corn, Lot (3) 4.5 parts of molasses in place of 3 parts of corn in the basal ration. Average daily gains were: Lot (1), 1.12 lbs., Lot (2) 0.98 lbs., and Lot (3) 1.08 lbs. per hog over a 51-day test period.

336. Bohstedt, G., Roche, B. H., Fargo, J. M., Rupel, I. W.,

Fuller, J. G., and Newman, P. E., **Molasses incorporated in grain mixtures.** *Proc. Am. Soc. Animal Production.* 1933:52. (1934); *Wisconsin Agr. Exp. Sta. Bul.* 428. (1934).

Ten per cent molasses in grain mixtures for dairy cows, fattening steers and lambs and growing and fattening pigs did not result in significant differences in gains or market production. In all cases except self-fed lambs slightly more feed was required to produce 100 lb. gain on the molasses rations.

337. Bohstedt, G., Roche, B. H., and King, W. A., **Molasses proves an expensive hog feed.** *Wisconsin Agr. Exp. Sta. Bul.* 440:15-6. (1938).

"Molasses was worth about one-half as much as corn when used to replace one-third the corn in a hand-fed pig ration." There was very little difference in feeding value between beet, cane, and corn molasses.

338. Brante, L., **Poisoning of swine by too heavy molasses feeding.** *Tidskr. Landtman.* 19:758-60. (1898).

Three fattening pigs, 7 to 9 months old, fed for 3 weeks on molasses feed (bran, palm-nut meal and molasses, 1:1:2) suddenly became ill and were killed in a dying condition. The presence of high potassium salts in the molasses was ascribed as the cause.

339. Burns, J. C., **Hog feeding experiments.** *Texas Agr. Exp. Sta. Bul.* 131:7-33. (1909).

Blackstrap molasses was compared with corn for fattening hogs. In a 90-day test with 24 Yorkshires, 8 to 10 months of age, one lot fed corn alone gained 1.66 lbs. per day at a cost per lb. of 7.36 cents. A lot receiving 3 parts corn and one part molasses made an average daily gain of 1.45 lbs. at a cost of 7.53 cents per lb.; a third lot receiving half molasses and half corn gained 0.9 lbs. per day at a cost of 10.75 cents per lb. of gain.

340. Carroll, W. E., **Beet molasses as a feed for weanling pigs.** *Trans. Utah Acad. Sci.* 1:205. (1908-17). (1917).

Thirty pigs, between 9 and 12 weeks of age, were divided into 3 uniform lots and fed a basal diet of 2 parts ground barley and 3 parts wheat shorts. (1) Basal alone. (2) Basal plus 1 lb. beet molasses per 100 lbs. live weight. (3) Basal and 2 lbs. beet molasses per 100 lbs. live weight. After about 1 month, 2 pigs in Lot (3) died. The first death in Lot (2) occurred after about 2 months. At the close of the experiment, Lots (2) and (3) each contained only 3 live pigs, while none had died in Lot (1).

**341.** Carroll, W. E., and Burroughs, W., **Molasses fails to replace corn in hog-feeding trial.** *Illinois Agr. Exp. Sta. Rpt.* **1936/37**:114. (1937).

Cane molasses was substituted for different amounts of corn in a hog-fattening ration. Twenty and 30% molasses were used to replace corn in the basal ration. The molasses-fed pigs required from 2 to 3 weeks longer than the control lot to reach market weight. Each 100 lbs. of molasses fed to pigs on the 20% molasses ration was calculated to replace only 12 lbs. of grain and on the 30% molasses ration, 21 lbs. of grain.

**342.** Cunha, T. J., Pearson, A. M., Glasscock, R. S., Buschman, D. M., and Folks, S. J., **Preliminary observations on the feeding value of citrus and cane molasses for swine.** *Univ. Florida Agr. Exp. Sta. Circ.* **S-10**:1-6. (1950).

Five experiments with purebred Duroc pigs 4 per lot, showed that either cane or citrus molasses can satisfactorily replace part of the corn in a growing ration for swine. Cane molasses at 10%, 20% and 40% substitution for corn in the ration showed feeding values of 97, 70 and 74% corn, respectively. It is recommended that in animals weighing 40 to 100 lbs., 10% of the corn can be replaced by molasses; from 100 to 150 lbs., 20% replacement; and from 150 to 200 lbs., pigs can utilize molasses at a level replacing 40% of the corn.

**343.** Dickson, D., and Malpeaux, L., **The use of molasses in feeding animals.** *Ann. agron.* **24**:353-81. (1898).

The authors conclude from their experiments that when molasses formed a part of the ration of sheep, pigs and steers the gains in

live weight were rapid. When molasses was fed to milk cows the total milk yield and amount of fat and milk sugar in the milk was increased. Molasses may be advantageously employed for rendering inferior hay or fodder more palatable.

**344.** Faye, G., and Frederiksen, E., **Beet molasses feed for pigs.** *Ugeskr. Landmaend.* **42**:15-7. (1897)

Four lots of 5 pigs averaging 25 lbs. were given a basal diet of buttermilk and whey (or skim milk). Lot (1) also received corn and barley; Lot (2), two-thirds corn and barley, one-third molasses feed (palm-nut cake, wheat bran and molasses, (1:3:4); Lot (3), one-half grain and one-half molasses feed; Lot (4), one-third grain and two-thirds molasses feed.

Results:

| Lot No. | Average daily gain | Cost per lb. gain |
|---|---|---|
| 1 | 1.02 | 4.2¢ |
| 2 | 1.01 | 4.07¢ |
| 3 | 0.97 | 4.2¢ |
| 4 | 0.92 | 4.3¢ |

The quality of the meat of the lots fed molasses feed was judged by an expert to be excellent.

**345.** Faye, G., and Frederiksen, E., **Molasses as a feed for swine.** *Ugeskr. Landmaend.* **43**:134-9. (1898).

Forty pigs were divided into 2 lots of 20 each. One lot was fed Indian corn and the other barley. In each case molasses feed (palm-nut meal, wheat bran and molasses, 1:3:4) was substituted for one-third of the grain ration of part of the pigs. The test indicated that beet molasses, when not fed too heavily, is an economical food for swine, its feeding value being equivalent to about three-fourths that of grain feeds, pound for pound.

**346.** Ferrin, F. E., **Cane molasses in hog ration.** *Minnesota Agr. Exp. Sta. Mimeo. Rpt.* **H-70.** (1937).

**347.** Fjeldsted, E. J., and Potter, E. L., **Finishing pigs for market.** *Oregon Agr. Exp. Sta. Bul.* **165**:15. (1919).

Hogs, averaging 183 lbs., fed a ration consisting of 72% barley, 8% tankage and 20% molasses made an average daily gain of 2.11 lbs. over a 50-day test. Molasses proved to be practically equal, pound for pound, to ground barley when used in this manner for fattening hogs.

348. Frederiksen, E., **Molasses as food for swine.** *Ugeskr. Landmaend.* **No. 28**; *Milch Ztg.* **25**; No.35:556-8. (1896).

Three lots of five 70-pound pigs were fed a diet of buttermilk and whey supplemented with barley in Lot (1); barley and molasses feed (palm-nut cake, bran and molasses, 1:3:4) in Lot (2); and barley and molasses feed (at a higher level) in Lot (3). At the end of 80 days all pigs had made approximately equivalent gains, but the lot receiving the molasses at the higher level cost considerably less to produce. It was concluded that molasses was a profitable feed ingredient for pigs over 50 lbs.

349. French, R. B., Pearson, A. M., Cunha, T. J., Schmidt, V., Abbott, O. D., Anderson, C. L., and Glasscock, R. S., **Effect of feeding citrus or cane molasses on carcass quality and the content of certain vitamins in pork.** *J. Animal Sci.* **8**:612. (1949).

Using a basal ration of: cornmeal, 71.5; peanut meal, 17; alfalfa meal, 10; minerals, 1.5% for fattening pigs weighing 150 lbs., 40% of ration was replaced by either citrus or cane molasses. Feeding value of citrus and cane molasses appeared to be equal, being 78% as valuable as corn by weight.

350. Friis, F., **Danish feeding experiments with swine, 1859-98.** *Kgl. Vet. and Landbohojsk. Lab. Landokon. Forsog, Copenhagen. Rpt.* **42**:162. (1899).

Molasses feed made from palm-nut meal, wheat bran and beet molasses (1:3:4) was compared with barley and Indian corn as a feed for pigs. Molasses feed produced a similar, but cheaper gain in weight and improved the quality of the pork produced.

351. Frohlich, G., and Haring, F., **Protein sparing effect of molasses in growing pigs.** *Ztschr. Schweinezucht.* **42**:823-8. (1935); *Kuhn-Arch.* **40**:1-25. (1935).

Two experiments are described in which molasses replaced one-fifth of the herring meal or of the meat and fish meals in the ration of suckling pigs, 4-10 weeks old and of 33-100 Kg. pigs as well. In both cases this replacement was unsatisfactory. There was no protein-sparing effect.

**352.** Gayden, H. P., **Blackstrap molasses—A poor feed for hogs.** *Proc. Assoc. Southern Agr. Workers.* **37-38**:91. (1936/37).

Two trials were conducted using 5 lots of 4 pigs each. The basal diet consisted of 90 parts corn, 5 parts cottonseed meal and 5 parts shrimp meal. In the first trial, a 25% substitution of molasses for corn proved to be excessive. In the second trial, molasses replaced corn at the rates of 5, 10, 15, and 20%. The pigs receiving the corn ration made an average daily gain of 1.22 lbs. per pig. Those receiving the various levels of molasses gained 1.16, 1.17, 1.17, and 1.06 lbs. respectively. The efficiency of feed utilization decreased with increasing levels of molasses.

**353.** Gerlach, M., Jahresber, *Landw. Vers. Sta. Jersitz-bei-Posen. 1898/99; Centrbl. Agr. Chem.* 30:104. (1901).

Pigs fed corn germ and molasses made better gains than those fed grains.

**354.** Gervacio, E. T., **Further studies on molasses as hog feed.** *Philippine Agr.* **30**:492-8. (1941).

Molasses vs. rice bran in rations for growing and fattening pigs. Analyses of cane molasses showed it to contain: $H_2O$, 35.68; protein, 1.22; ether extract, 0.26; nitrogen-free-extract, 54.01; and ash, 8.83%. Its calorific value was found to be 229 calories per 100 gms.

**355.** Gochangco, D. R., **A comparative study of corn and molasses as basal feeds for swine.** *Philippine Agr.* 21:560-71. (1933).

For growing pigs and gilts, cane molasses and shelled corn were found to have equivalent feeding value, weight for weight. Cane molasses appeared to promote better plumpness, smoothness and

general finish and was, therefore, recommended in place of corn in preparing animals for show purposes.

356. GRIMES, M. F., **Experiments in swine feeding at the Pennsylvania Station.** *Pennsylvania Agr. Exp. Sta. Bul.* 213:13-4; 215:15. (1927).

For fattening hogs, shelled corn and tankage; shelled corn, molasses and tankage; stale bread and tankage; and stale crackers and tankage were about equal in producing gains.

357. HACKEDORN, H., and SOTOLA, J., **Hog feeding experiments.** *Washington Agr. Exp. Sta. Bul.* 169:32. (1922).

Cane molasses was an efficient substitute for one half the barley, pound for pound, when the hogs were also on pea forage, but did not prove so efficient in dry lot.

358. HENKE, L. A., **Comparative value of pineapple bran, cane molasses and barley as feeds for fattening hogs.** *Hawaiian Univ. Quart. Bul.* 7 (1):15-7. (1928).

359. HENKE, L. A., **Molasses for fattening hogs.** *Hawaiian Univ. Quart. Bul.* 8 (4):32-5. (1929).

360. HENKE, L. A., **Cane molasses as a supplement to fattening rations for swine.** *Hawaiian Agr. Exp. Sta. Bul.* 69:11. (1933).

Using a based ration consisting of rolled barley, 88%; tankage, 8%; linseed oil cake meal, 2%; salt, 1%; and steamed bone meal, 1%, 4 experiments were conducted with feeder pigs in which the basal diet was fed alone and supplemented with 10 and 20% of cane molasses in place of barley. Average daily gains were: Experiment I. (1) (Basal diet) 1.43 lbs. (2) (10% molasses) 1.16 lbs. and (3) (20% molasses) 0.92 lbs. using 6 pigs per lot with an average initial weight of 70 lbs. over a 70-day test. Experiment II. (1) (Basal diet), 1.50 lbs. and (2) (10% molasses), 1.64 lbs. using 4 pigs per lot with an initial weight of 102 lbs. over a 70-day test. Experiment III. (1) (Basal diet) 1.03 lbs.; (2) (10% molasses), 1.12 lbs. using 5 pigs per lot having an average initial weight of 49 lbs. over

a 126-day test. Experiment IV. (1) (Basal diet), 1.36 lbs.; (2) (10% molasses), 1.44 lbs.; (3) (20% molasses), 1.45 lbs. using 5 pigs per lot having an initial weight of 81 lbs. over a 76-day test. In all except the first experiment, the molasses showed a value, pound for pound, which ranged from 103.2% to 111.6% that of barley. In the first experiment, molasses was approximately 95% as valuable as barley.

**361.** Henke, L. A., and Goo, G. W. H., **Pineapple bran-molasses mixtures for fattening swine.** *Hawaiian Sta. An. Husb. Div. Prog. Notes.* **No.11.** (1935); *Hawaiian Agr. Exp. Sta. Ann. Rpt.* **1936**:71. (1936).

This was a test of pineapple bran since all rations used contained molasses.

**362.** Hughes, E. H., and Lindsay, M. A., **Fattening tests with 100 lb. feeder pigs in dry lot.** *Univ. of California Ext. Serv., Tulare County* (in cooperation with the College of Agr.). (1930).

Three lots of 6 pigs each were fed (1) a basal diet of barley, 10% alfalfa and minerals; (2) basal diet with 10% molasses substituted for barley; (3) 25% molasses substituted for barley. Averaged daily gains per pig were: (1) 1.60, (2) 1.53 and (3) 1.28 lbs. over a 56-day test period. The dressed weights were: (1) 74.6, (2) 75.7 and (3) 76.3 lbs. The fat was described as hard in each of the lots.

**363.** Hunter, J. M., **Value and economy of molasses in the brood sow ration.** *New Jersey Agr. Exp. Sta. Rpt.* **38**:111-4. (1917).

Four lots of 6 sows, 2 to 4½ years old were fed diets of equivalent nutritive ratio in which in 2 lots molasses replaced part of the corn-meal or hominy feed. The diets were as follows: (1) corn, tankage, mangels and alfalfa hay; (2) corn, alfalfa meal, molasses (blackstrap) and mangels; (3) hominy meal, alfalfa meal, blackstrap molasses, mangels and alfalfa hay; (4) alfalfa meal, tankage, alfalfa hay, mangels and molasses. The average daily gains per sow were (1) 0.686, (2) 1.04, (3) 0.67 and (4) 0.49 lbs. Thus, the lots receiving molasses were as good as those without, except where all of the corn was replaced with molasses in which case the pigs scoured and grew at a much slower rate.

364. Husby, M., **Molasses as food for pigs.** *Landbrukhogsk. Ins. husdyrernoering foringsloere. Rpt.* **No. 11**:3. (1941); *Norsk Landbruk Rpt.* **1941**:471-3. (1941).

Basal diet of oats, coconut cake, sunflower meal and fish meal as 50% of the total diet plus 2 Kg. potatoes per animal per day as the other 50%. This ration was fed alone and supplemented with 18% and 46% of molasses from the time the pigs were 70-80 Kg. up to slaughter at 117-125 Kg. Gain and feed consumption were about equal in all groups. Per cent slaughter weight was lower and pork was softer and somewhat discolored in the pigs which received molasses, especially at the high level. It was concluded that molasses, is a useful feed for bacon pigs when the amount doesn't exceed 20% of the ration or 0.5 to 0.75 Kg. per day. Under these conditions the quality of the pork was only slightly reduced.

365. Jagoda, G., **Fodder tests with addition of (beet) raw sugar and molasses, also saccharin.** *Z Ver. Dent. Zucker-Ind.* **1927**:243-331. (1927).

Using a basal ration of fish meal, barley and potatoes; experiments were conducted with pigs in which sugar, beet molasses and saccharin were fed. Both the sugar and the molasses caused increased gains in weight to the extent that the fattening period could be reduced by 7 days. Saccharin caused only slight increases in feed intake and growth.

366. Lindsey, J. B., Holland, E. B., and Smith, P. H., **Molasses and molasses feeds for farm stock.** *Massachusetts Agr. Exp. Sta. Bul.* **118**:31. (1907).

The feeding value and digestibility of molasses are discussed on the basis of work as the Mass. Station and elsewhere. Favorable results are reported in tests with horses, pigs, and milk cows. It is especially recommended for use with unpalatable feeds. "If molasses is used for - - pigs, it must be mixed with foods reasonably rich in protein."

367. Luke, D., and Gordon, W. A. M., **Observation on some pig diseases. So-called "gut-edema." An exzematous condition**

**of suckling pigs. Ascarid infestation in pigs. Piglet anemia. Trembling in young pigs.** *Biol. Abs.* **25**:11450. (1950).

A preventive method is to paint the sow's udder with ferrous and copper sulfate and molasses anemic formula to which riboflavin and niacin have been added.

**368.** Machado, F. P., **Fattening swine with cane molasses.** *Swine World.* **7**:18-9. (1919).

Instructions concerning the use of cane molasses in the feeding of pigs, based largely on the author's farm experience.

**369.** Malkomesius, P., **Feeding studies on swine using ground linseed-hull chaff and linseed-hull chaff treated with molasses.** *Zuchtungskunde.* **13**:191-9. (1938).

In swine receiving a basal diet of a protein concentrate and potato-flake, the addition of linseed-hull chaff and molasses at levels of 0.50-0.75 Kg. per day caused an increase in growth.

**370.** Mangold, E., Columbus, A., and Peham, A., **Digestibility and biological value of protein of fresh and preserved brewing yeasts as determined in tests with hogs and ruminants.** *Biedermanns Zentr. B. Tierernahr.* **13**:189-210.

Brewer's yeast mixed with molasses at 2:3 proved to be a stable product with 50% dry matter, of which 25% was protein and 63% NFE. Digestibilities of 72 and 98%, respectively, were obtained for this mix in feeding trials with sheep and hogs.

**371.** Minkler, F. C., **Feeding experiments with swine.** *New Jersey Agr. Exp. Sta. Rpt.* **1916**:113-32. (1916).

In a 31-day feeding test, 3 lots of brood sows, 7 per lot, were fed: (1) 1,302 lbs. corn, 310 lbs. alfalfa hay and 1,080 lbs. mangels; (2) 1,302 lbs. corn, 310 lbs. alfalfa hay, 662 lbs. tankage and 1,080 lbs. of mangels; (3) 1,550 lbs. of equal parts of ground alfalfa hay and blackstrap molasses, 73.78 lbs. tankage and 1,080 lbs. mangels. Average daily gains per sow were (1) 1.078 lbs., (2) 0.875 lbs., (3) 1.43 lbs., and the costs per lb. of gain were: (1) 10.47, (2) 13.72 and

(3) 5.45 cents. In another experiment, using breeding gilts, 2 lots of 5 uniform gilts were fed: (1) corn, tankage and alfalfa hay and (2) the same proportion of nutrients in the form of molasses and ground alfalfa with limited amounts of tankage. Lot (1) gained 0.822 lbs. per pig pe rday at the rate of 3.95 lbs. of feed per lb. gain; (2) gained 0.69 lbs. per pig per day and at the rate of 5.83 lbs. feed per lb. gain.

372. Pollock, F. O., **Molasses—A feed for livestock.** *Flour & Feed.* **37,** No. 7:18. (1936).

The advantages and methods of feeding molasses to hogs are described.

373. Rasmussen, R. A., **Vitamin deficiencies in sugar-beet molasses.** *Farm & Home Sci. (Utah Agr. Exp. Sta.)* 3:2,4. (1942).

Hogs weighing 100 lbs. or more made satisfactory and inexpensive gains on a ration of 40 parts beet molasses; barley, 45; tankage, 8; alfalfa, 5; salt, 1; and bonemeal, 1. This diet was not adequate for younger pigs unless supplemented with 5% yeast.

374. Rasmussen, R. A., Smith, H. H., Phillips, R. W., and Cunha, T. J., **Nutritional inadequacy of beet molasses rations for swine.** *Utah Agr. Exp. Sta. Bul.* **302**:5-22. (1942); *Flour & Feed.* **41,** No.2:22. (1940).

A nutritional disease characterized by a staggering gait was encountered on replacing 15% or more of grain with beet molasses. Supplementation with 5% yeast or green alfalfa made diet complete. Pigs weighing 25-50 lbs. showed symptoms in 20-30 days, usually. Apparently disease results from lack of an unknown vitamin. Hogs weighing 100 lbs. or more do not develop the disease. Sows fed the diet farrowed affected young.

375. Robison, W. L., **Molasses for pigs.** *Ohio Agr. Exp. Sta. Bul.* **516**:82. (1933).

In a single trial pigs fed a ration containing 2.5 molasses made a poorer showing than pigs receiving the diet without molasses.

376. Slagsvold, P., **Nutritional disease in swine by feeding**

**great amounts of molasses. Possible thiamin deficiency in pigs on rations containing silage preserved with formic acid.** *Kgl. Lantbrukshogsk. Ann.* **15**:251-90. (1948).

Five groups of 5 young pigs were given a basal diet of barley and tankage, alone or supplemented with $K_2CO_3$, or molasses, or molasses and yeast, or molasses and silage made with formic acid. Growth was retarded, and in all groups receiving molasses in place of 50% of the grain, growth was very poor and irregular. Sign of incoordination and severe diarrhea occurred. These symptoms were somewhat relieved by yeast and greatly aggravated by the silage. Blood pyruvic acid was high in all animals receiving molasses. Injections of thiamin improved appetite, growth and general condition in pigs receiving molasses and silage.

377. Snell, M. G., Upp, C. W., and Lush, R. H., **Blackstrap molasses as a livestock feed.** *Louisiana Agr. Exp. Sta. Circ.* **19**: 2-3. (1937).

Molasses was fed to hogs to replace shelled corn at rates of 5, 10, 15, 20, 25, 50, 75 and 100%. In none of these trials did molasses show any appreciable feeding value. Basal ration was not given.

378. Stahl, W., **Cultivation of the sugar beet and its value for the feeding of hogs.** *Zuckerrubenbau.* 22:115-20,121-6. (1940); *Chem Zentr.* **I**:592. (1941); *C.A.* **36**:7174. (1942).

A mixture of potato and sugar beet slices was found to be of value in replacing barley and corn. Data are given on food value of dried sugar beets, dried sliced sugar beets and molasses.

379. Templeton, G. S., and Greene, S. W., **Swine feeding experiments at the Mississippi Station.** *Mississippi Agr. Exp. Sta. Rpt.* **1925**:15-6,56. (1925).

Two lots of 20, 50-lb., hogs were fed corn and tankage with and without supplemental cane molasses which was hand-fed twice daily at a level equivalent to 0.5% of the live weight of the animals. The average daily gain over a 98-day period was 1.49 lbs. for the lot without and 1.44 lbs. for the lot receiving molasses.

380. Thompson, C. P., **Molasses tested in combinations with oats and corn for hogs.** *Oklahoma Agr. Exp. Sta. Rpt.* 1936/38:47-8. (1938).

It was observed that pigs relished a combination of oats and molasses much more than a combination of corn and molasses. The conclusions are drawn that "the nutritive value of molasses, when making up 20% or more of a ration consisting of corn, or oats, tankage and alfalfa hay is somewhat less than the chemical analysis would indicate."

381. Thompson, C. P., **Blackstrap molasses as a substitute for corn in fattening hogs.** *Proc. Am. Soc. Animal Production* 30:113-5. (1937).

In rations containing wheat shorts, corn and minerals, replacing part of the corn with blackstrap molasses, increased daily gains and greatly decreased cost of production. Total replacement of corn with molasses was possible and, although in this case growth was not increased, a very marked saving in costs was realized. Feeding value of molasses was found to be 84% that of corn. Some scouring occurred during the initial stages of molasses feeding.

382. Thompson, C. P., and Hillier, J. C., **Blackstrap molasses as a partial substitute for corn and oats in fattening rations for swine.** *Proc. Am. Soc. Animal Production* 31:146-9. (1938); *Oklahoma Agr. Exp. Sta. Bien. Rpt.* (1937/38).

Pigs preferred mixture of oats and molasses to one of corn and molasses and those receiving corn and molasses scoured, others did not. The average daily gains of pigs fed oats and molasses increased whereas those on corn and molasses decreased. In both cases, utilization was poorer in presence of molasses than without.

383. Walker, G. B., **Some experiments and practical demonstrations in hog feeding at the Delta Branch Experiment Station.** *Mississippi Agr. Exp. Sta. Bul.* 177:16, (1916).

In a test of blackstrap molasses as a substitute for corn, 3 pigs fed corn and cottonseed meal (5:1) gained 1.76 lbs. per head per day for 60 days at a cost of 4.82 cents per lb. of gain. During

the same period 3 pigs fed molasses and cottonseed meal (1:1) gained 1.2 lb. per head per day at a cost of 7.1 cents per lb. of gain. Each of the lots received the same amount of cottonseed meal.

384. WARE, L. S., **Cattle feeding with sugar beets, sugar molasses and sugar beet residuums.** Philadelphia Book Co. Philadelphia 1902.

An excerpt on the feeding of molasses to pigs (p.246): "Very little data has been published respecting experiments in pig feeding, but those that are known may, upon general principles, be considered favorable. —Experience shows that it is not desirable to feed pigs with molasses until they weigh at least 50 Kg. When this weight is reached one may feed 1% of their weight of this product. Sows, on the other hand, should not be allowed more than 0.5%. Molasses produces an excellent meat when fed at the same time as corn, and under no circumstances should it ever be lacking in a pig-feeding establishment. However, certain precautions are necessary so as not to push this quantity to an excess, as in reaching a limit of 3% there are dangers of intestinal complications, which means an impossibility of sausage-making."

385. WAYMAN, O., LEONG, K. C., **The use of byproducts of territorial industries in swine rations.** *Hawaiian Agr. Exp. Sta. Progress Notes.* **85.** (1952).

A mixture of blackstrap molasses and bagasse pith in the ratio of 10:1 was not a satisfactory ingredient in the ration of either weanling or 85 lb. pigs. However, "B" grade molasses (which contains less ash) was found to be very satisfactory.

386. WEAVER, L. A., **Cane molasses as a feed for pregnant sows.** *Missouri Agr. Exp. Sta. Bul.* 370:13-4. (1936).

A molasses-containing ration did not give good results in the farrowing of baby pigs. However, no control ration (not containing molasses) was fed.

387. WILLETT, E. L., HENKE, L. A., and MARUYAMA, C. I., **Cane molasses for weanling pigs.** *Hawaiian Agr. Exp. Sta. Bien. Rpt.* **1944/46**:40. (1946).

Using the same basal ration employed in the 1941-42 and 1943-44 studies, a third experiment was conducted to determine whether or not weanling pigs could tolerate 30 and 40% molasses. At these levels, growth was retarded significantly.

388. Willett, E. L., Henke, L. A., and Maruyama, C. I., **Swine experiments. Garbage supplemented with molasses.** *Hawaiian Agr. Exp. Sta. Bien. Rpt.* **1944/46**:42. (1946).

Using 7 pigs per lot, an experiment was conducted to determine the amount of molasses that could be added to military garbage. Levels of: (1) 0, (2) 10, (3) 20, and (4) 30% molasses were used. The average daily gains were: (1) 1.19, (2) 1.06, (3) 0.94, and (4) 0.82 lbs. over the 154-day experimental period. The decreasing rates of gain with increasing levels of molasses were attributed to the decreasing amounts of protein.

389. Willett, E. L., Work, S. H., Henke, L. A., and Maruyama, C. I., **Cane molasses for pigs from weaning to a weight of seventy pounds.** *Hawaiian Agr. Exp. Sta. Tech. Bul.* 3. (1946).

A basal ration, containing 15 to 16% protein was fed with and without various levels of molasses to weanling pigs. In experiment 1 using 10% molasses, there were no differences in weight or feed efficiency between control and molasses groups. However, the molasses feed was cheaper. In experiment 2 there was no difference between the control and the lots receiving either 10% or 20% molasses, but it took some time for the pigs to become adjusted to rations containing more than 10% molasses. Higher levels of molasses, 30 and 40%, were unsatisfactory. Therefore, the maximum level appeared to be 20% for best gains and efficiency of feed utilization.

390. Woodman, H. E., and Evans, R. E., **The nutrition of the bacon pig. IX. The Lehmann method of pig feeding, with particular reference to the balance of the basal meal and the use of cooked potatoes and molassed beet pulp as the supplemental foods.** *J. Agr. Sci.* 33:155-68. (1943).

Because of its bulkiness, molasses beet pulp was less satisfactory than cooked potatoes. It was concluded that a 200 lb. pig could not be expected to deal with more than 3 lbs. of molassed beet pulp in addition to 3 lbs. of basal meal.

391. Work, S. H., and Henke, L. A., **Pineapple sirup and cane molasses for fattening (swine).** *Hawaiian Agr. Exp. Sta. Ann. Rpt.* **1940**:30-1. (1940).

Sixty pigs averaging 62 lbs. were divided into 6 lots of 10 pigs each. The pigs had free access to fresh green feed or alfalfa hay. Levels of molasses were varied from 10% to 20% of the ration until the pigs reached 100 lbs. body weight. Whereupon they were increased to 20, 40, and 50%. The 50% level proved to be too laxative, but good results were obtained by replacing barley with either 20 or 40% molasses.

392. Work, S. H., Henke, L. A., and Maruyama, C. I., **Cane molasses for weanling pigs.** *Hawaiian Agr. Exp. Sta. Bien. Rpt.* **1941/42**:29. (1942).

Two lots of pigs were fed a good basal diet (consisting of barley, 48; middlings, 20; tankage, 15; soybean meal, 5; and salt and bone meal 1 each) supplemented with (1) 10% sugar and (2) 10% cane molasses. No ill effects resulted from feeding molasses to weanling pigs and the average daily gains per pig were 0.83 lbs. on the sugar ration and 0.88 lbs. on the molasses ration over a 47-day growth period.

393. Work, S. H., Willett, E. L. Maruyama, C. I., and Henke, L. A., **Cane molasses for weanling pigs.** *Hawaiian Agr. Exp. Sta. Bien. Rpt.* **1943/44**:93. (1944).

Using a basal diet similar to that used in the previous study (Work, Henke and Maruyama, 1941-42) except that fresh grass was also fed, 1 lb. per day, a second experiment was conducted in which a supplement of (1) 10% sugar was compared to (2) 10% and (3) 20% molasses. There were 13 weanling pigs per lot. The average daily gains per pig were (1) 0.88, (2) 0.84, and (3) 0.88 lbs. and the TDN per pound of gain were equivalent for all lots.

## MOLASSES IN RATIONS FOR POULTRY

### Molasses in Mixed Poultry Mashes

394. Bearse, G. E., **A comparison of molasses, whey, con-**

densed buttermilk, and condensed buttermilk containing cereal grasses as supplements to a breeding hen ration. *Poultry Sci.* 17:433-4. (1938).

Duplicate lots of 34 ten-month white Leghorn pullets each were fed the following ration: cornmeal, 15; ground wheat, 15; ground oats, 10; millrun, 27; dehydrated alfalfa, 10; meat scrap, 6.5; fish meal, 6.5; skim milk, 5; oyster shell, 2; bone meal, 2; salt, 1 plus vitamins A & D and 50-50 scratch grains. Additional duplicate lots were fed 4% dehydrated cane molasses, 5% whey, 3 lbs. condensed buttermilk (with and without grass) per 100 hens per day. All except dehydrated molasses increased hatchability over a 12 week period.

395. Bice, C. M., **Cane molasses in poultry rations.** *Hawaiian Agr. Exp. Sta. Bul.* 67:16. (1933).

Four lots of 250 chicks each were fed a commercial mash and grain ration supplemented with codliver oil, grit, bone meal, oyster shells, charcoal and chopped green alfalfa. In addition, the lots received: (1) 0, (2) 5, (3) 7, and (4) 10% of molasses. The average weights at 6 weeks and (with cockerels removed) at 13 weeks were approximately equal for all lots. In fact, the pullet weights at 13 weeks for the lots receiving 5 and 7% molasses were somewhat superior to those of the control lot and the lot receiving 10% molasses. Therefore cane molasses was considered to be a satisfactory feed for chicks, growing pullets and cockerels when fed in amounts not to exceed 7% of the ration. Levels of molasses up to 15% resulted in economical gains when incorporated in fattening rations for broilers maintained in batteries. Ten per cent molasses in laying rations produced watery droppings.

396. Bice, C. M., **Cane molasses in laying rations.** *Hawaiian Agr. Exp. Sta. Ann. Rpt.* 1938:83. (1938).

Single comb white Leghorn pullets were fed 0, 3, 5, and 7% cane molasses added to a standard laying ration. During 2 successive years the data indicated that the groups of hens receiving 3% molasses had the highest egg production and the greatest returns above feed cost per hen.

397. Bice, C. M., and Dean, L. A., **Salt balance of molasses feed.** *Hawaiian Agr. Exp. Sta. Ann. Rpt.* **1939**:82. (1939).

Excessive amounts of molasses in rations give rise to diuretic effects. In order to determine the amount of molasses which can be added to feeds without causing these effects, a preliminary experiment was conducted with salt mixtures in synthetic (poultry) diets. Excessive amounts of either sodium or potassium chloride caused diuretic effects.

398. Bice, C. M., and Tower, B. A., **Molasses being tried in chick and fattening rations.** *Hawaiian Agr. Exp. Sta. Ann. Rpt.* **1936**:78. (1936); **1937**:81-2. (1937).

Three lots of over 100 chicks each were fed molasses added in varying proportions to an all-mash chick ration: Lot (1) 3% molasses, Lot (2) 5% molasses, Lot (3) 7% molasses, Lot (4) no molasses. Only results given are in terms of economy of the use of molasses. "With corn meal at $49.00 per ton and molasses at about $5.00 per ton, substitution of molasses resulted in considerable saving".

399. Camp, A. A., and Stephenson, E. L., **An unidentified chick growth factor found in corn hydrol.** *Poultry Sci.* **31**:910. (1952).

The feeding of corn molasses as a replacement of 10% of the corn in a soybean meal—corn diet supplemented with all known factors caused a significant increase in chick growth. Since milo molasses did not promote a similar growth increase, it was concluded that corn molasses contains an unknown growth factor.

400. Cooney, W. T., and Parker, J. E., **Wood sugar molasses as a feedstuff for laying hens.** *Poultry Sci.* **31**:343-50. (1952).

Seven and one-half per cent wood sugar molasses, replacing equal amount cereal grain, caused increased food consumption and corresponding increased egg production. Feed per doz. eggs was the same as the control. Fifteen per cent wood sugar molasses proved to be too much, causing decreased egg production. Also, 75% wood sugar molasses plus 75% beet pulp decreased egg production.

Hatchability was increased from 76.5% of fertile egg by controls to 86.0% of fertile eggs by feeding 7.5% wood sugar molasses.

401. Dixon, F., **Cane molasses and cocoanut oil meal as constituents of poultry rations.** Unpublished Special Research Project, under the direction of C. R. Grau, University of California.

Using a basal diet consisting of: milo, 40; corn, 15; cocoanut oil meal, 10-20; soybean oil meal, 20-10; fish meal, 7; distillers dried solubles, 1; alfalfa meal, 4%; plus adequate supplementation with necessary vitamins and minerals, 2 experiments were conducted with single comb white Leghorn chicks to test the value of molasses as a replacement for corn. At levels of 5 to 10%, molasses produced a rate of growth equal to or superior to that obtained on the basal diet. At the 10% level, molasses produced a laxative effect, but the droppings were not sticky.

402. Ferber, K. E., and Chodziesner, M., **Fattening young geese with sugar beet slices, mixed molasses feed and skimmed milk.** *Arch. f. Geflugelk.* 7:177-84. (1933).

Dried sugar beets (50% of ration) may be used with sour skim milk, as sources of protein together with young clover or alfalfa. Skim milk may be replaced by soybean meal. Palm kernel molasses meal (50% of ration) with sunflower seed meal (30%) wheat bran (18%) and chalk (2%), with green feed, gave good results in fattening geese.

403. French, M. H., **The feeding of poultry when normal foods are scarce.** *E. African Agr. J. Kunya, Tanganyika, Uganda, Zanzibar.* 10:152-8. (1945); *C.A.* 40:1249. (1946).

Estimates of starch value, digestible protein and dry matter of molasses and other materials for use in poultry feeds.

404. Gericke, A. H., **The feeding of molasses to poultry.** *Rhodesia Agr. J.* 37:324. (1940).

The use of one-half pound of molasses mixed with a gallon of water in the preparation of wet mash was found to stimulate appetite and egg production in chickens.

405. Graham, W. R., **Poultry.** *Ann. Rpt. Ontario Agr. Col. & Exp. Farm.* 32:201-10. (1906).

The value of different feed mixtures, some of which contained molasses, was tested in a 2 weeks period with 9 lots of 12 chicks each. The greatest gain, 15.5 lbs. per lot, was noted on a ration of shredded wheat and corn meal, 1:1, mixed with molasses and sour milk, and the smallest gain, 6 lbs. per lot, on bread and sour milk. In later tests, however, mixed cereal grain rations without molasses appeared to give better results for "fleshing."

406. Gutteridge, H. S., **Methods and rations for fattening poultry. II. Experimental technique and comparative value of fattening rations.** *Sci. Agr.* 18:198-206. (1937).

The addition of 5% mutton fat to a fattening ration increased the gain of Barred Rock cockerels by 18% as compared to the control. On the other hand, the addition of 5% molasses did not affect gain in weight, feed consumption or increase in fat on this diet.

407. Hogsett, H. A., **Stop coccidiosis losses.** *Pacific Rural Press.* 1:320. (April 1939).

Recommendations are made for the prevention of losses from coccidiosis. In addition to frequent cleaning of poultry houses, it is suggested that "molasses bran" be substituted for the regular feed for at least a half-day.

408. Holst, W. F., and Newlon, W. E., (Revised by H. A. Almquist and T. H. Jukes), **Poultry feeding: principles and practice.** *California Agr. Exp. Sta. Bul.* 417. (1927, rev. 1935).

Either cane or beet molasses is a feed commodity that has a distinct value as an energy concentrate. It is, however, entirely lacking in protein. Owing to its high mineral content, a main constituent of which is potassium, it is highly laxative when fed in amounts exceeding 5% of the total rations.

409. Jalonen, A., **Molasses bran unsatisfactory in control of coccidiosis.** *San Joaquin Valley Poultryman.* (May 20, 1940); *Feedstuffs.* (Aug 3, 1940).

Several lots of 13 to 14 cockerels per lot were fed a regular mash, molasses bran, or a high milk ration. One lot on each feed treatment was infected by oral administration of sporulated coccidia. Mortality on the regular mash was 19% ; on the molasses-bran ration 23% ; on the high milk diet there was no mortality.

410. Junghern, E., **Blue comb or pullet disease.** *Everybody's Poultry Mag.* (Sept. 1942).

The author suggests as a treatment for pullet disease, the addition of molasses to the drinking water to the extent of 10% or the feeding of a wet mash composed of equal parts of rolled oats and wheat bran mixed with 10 to 30% of molasses and sufficient water to obtain a crumbly consistency. The wet mash is fed on alternating days of one week for about 3 hours after withholding feed for about 2 hours.

411. Lee, A. R., **Fattening Poultry.** *U.S.D.A. Bur. An. Ind. Bul.* **140**:23. (1911).

In a discussion on the color of milk-fed poultry, it is stated that molasses has been reported to give a deep-yellow color to (the skin and flesh of) poultry.

412. McGinnis, J. Mac Gregor, H. I., and Carver, J. S., **Wood sugar molasses as a feedstuff for chicks.** *Poultry Sci.* **27**: 459-61. (1948).

The following conclusions were drawn from studies with wood molasses: (1) It was a satisfactory substitute for cereals when protein was made up with soybean meal. (2) Twenty per cent levels did not have laxative effect.

413. Madsen, I. L., **The nutritional value of beet sugar molasses by-products.** *Poultry Sci.* **31**:925. (1952).

Steffen's filtrate was treated to remove glutamic acid. The remaining product (called liquid betaine concentrate. (LBC)) contained approximately 15.7% betaine HCl. Both a corn-soybean meal basal diet and a high-energy diet containing fish meal, meat scrap, and whey were supplemented with 1, 1½, 2, 3, and 4% LBC. All levels

improved growth on both diets. Feed efficiency improved in most cases. Optimum results were obtained with the 2% level. Although LBC contains 18% ash, tests showed that ash of LBC was not deleterious to growth at levels studied.

**414.** Maw, A. J. G., **Feeding cane molasses to growing chicks and laying hens.** *Sci Agr.* **13**:743-5. (1933).

Rations containing 0, 1.25, 5, and 6.25% cane molasses were fed to pullets with no appreciable effect on feed consumption. Egg production and mortality were lower and water intake higher in the lots fed molasses. At 1, 3.5, and 7% in rations for growing chicks, weights were essentially equal in all lots to 10 weeks, but feed intake was increased as level of molasses increased.

**415.** Norris, L. C., and Heuser, G. F., **The nutritive properties of poultry feedstuffs.** *Cornell Agr. Exp. Sta. Rpt.* **1935**:130. (1935).

Five to 10% of cane molasses could be substituted for an equal amount of cornmeal in laying rations. Ten per cent produced a slight, temporary diarrhea at the beginning of each experiment.

**416.** Ott, W. H., and Boucher, R. V., **Feeding-cane molasses as a constituent of poultry rations. II. Molasses for adult chickens.** *Poultry Sci.* **21**:536-9. (1942).

The performance of single comb White Leghorn hens during 24-72 weeks of age was not significantly influenced by varying the feeding of cane molasses from 0 to 6%. Performance of second generation hens was as satisfactory as that of first generation on these diets.

**417.** Ott, W. H., Boucher, R. V., and Knandel, H. C., **Feeding-cane molasses as a constituent of poultry rations. I. Molasses for growing chicks.** *Poultry Sci.* **20**:470. (1941); *Pennsylvania Agr. Exp. Sta. Bul.* **399.** (1940); *Poultry Sci.* **21**:340-5. (1942).

The mean performance of male and female chicks on all-mash diets containing 0, 2, 4, and 6% feeding-cane molasses were usually within limits of normal variation. There was evidence that the diet

containing 4% molasses had a slight early-growth stimulating effect on both sexes. Growth of 2nd generation on this diet was relatively slightly superior to growth of second generation on other diets. Total feed intake was increased significantly by inclusion of 4-6% molasses but feed efficiency was highest on no molasses diet. Diet was: corn, 42.3; bran, 15; wheat middlings, 10; oats, 10; alfalfa, 5; meat scrap, 7; fish meal, 7; skim milk, 2; lime, 1; salt, 0.5; cod-liver oil (400D), 0.2%. Molasses was composite from 1938 production of 14 Cuban sugar mills.

**418.** Peters, C. W., **Molasses bran for bloody coccidiosis.** *Feedstuffs.* (Dec. 23, 1939).

The experiences are given of a group of Southern California poultrymen in independent test on the effects of molasses bran (containing 15% molasses) upon coccidiosis. In 40 tests (no controls were used), the feeding of molasses bran in the morning followed by the regular mash for the remainder of the day, this treatment repeated for 3 successive days, appeared to reduce mortality to a very low figure.

**419.** Peters, C. W., **Molasses bran treatment.** *Feedstuffs.* (Aug. 17, 1940).

This article was written in order to point out that the failure of Jalonen (Feedstuffs, Aug. 3, 1940) to obtain satisfactory results with molasses bran in the treatment of coccidiosis was because he fed molasses bran as the total ration, which was not the suggested method of feeding and which failed to provide adequate nutrition.

**420.** Rice, J. E., and Botsford, H. E., *Practical Poultry Management.* 5th ed. New York. Wiley. 1949.

Molasses may be used to replace corn. Five per cent is satisfactory while 10% may cause temporary diarrhea. It is a potassium carrier and may be used therefore, to control blue comb. Molasses, 1 part per gallon of drinking water for several days followed by a wet mash 3 to 4 times daily of 50 parts ground oats, 50 parts wheat bran, 10 parts molasses, and 5 parts water.

**421.** Rosenberg, M. M., **Low-grade sugar, a potential carbo-**

**hydrate feedstuff for laying chickens.** *Poultry Sci.* 31:933. (1952).

Low-grade sugar was fed in graded amounts for a 20-week period to laying hens in 2 trials. When fed at 32.25, 45.5 and 56.0% of the total ration in partial or complete substitution for the cereal grains, it was found that the group receiving the 32.25% level laid significantly more eggs and more efficiently than did the controls. At the higher levels, however, egg production and hatchability were decreased and body weight was markedly increased.

422. Snell, M. G., Upp, C. W., and Lush, R. H., **Blackstrap molasses as a livestock feed.•Blackstrap molasses for poultry.** *Louisiana Agr. Exp. Sta. Circ.* 19:3-4. (1937).

Molasses was used in starting, laying and finishing or fattening rations in trials extending over a 4 year period. **Chicks:**—when fed to single comb white Leghorn chicks from 0-8 weeks at levels of 5, 10 and 15% it was found that 5% molasses gave as good results as no molasses but that 10 and particularly 15% was too laxative. The chicks relished the rations containing molasses. **Laying Rations:**—single comb white Leghorn pullets were fed 0, 5, 7.5, and 10% molasses in experiments over a 3 year period. Although the molasses caused damp and sticky droppings and litter, especially at 10% and caused pullets to drink more water, egg production, hatchability and liveability were as good or better in the lots receiving molasses. On the basis of these tests it is recommended to be used to replace corn in laying rations at a level of 15% in mashes to be used 50-50 with scratch grains or 7.5% in all-mash laying rations. **Finishing Rations:**—Using a fattening ration of cornmeal, 50; rice polishings, 35; dried buttermilk, 8; and cottonseed meal, 7% and replacing corn pound for pound with molasses at 10%, the molasses group put on weight as well as the control. The birds relished the feed containing molasses. Molasses, at this level was not laxative except when the ration was changed by replacing the cottonseed meal with additional buttermilk. Rhode Island Red hens, in good condition, were fattened for a 10 day period on this ration alone and with 15% molasses. The molasses group made the most rapid gains.

423. Upp, C. W., **Blackstrap molasses in poultry rations.** *Louisiana Agr. Exp. Sta. Bul.* 262:30. (1935).

Molasses was tested in rations for chicks, broilers and laying hens. When molasses was fed at more than 5% of the chick ration, decreased growth and lack of uniformity resulted. Fifteen per cent molasses caused considerable chick mortality. In laying rations, molasses at 7.5% of the total ration caused increased egg production as compared to similar rations without molasses. Rations containing 10 and 15% molasses yielded good results in the fattening of 8-week old cockerels.

**424.** Upp, C. W., **Blackstrap molasses and sweet potatoes in finishing rations for broilers.** *Proc. Assoc. Southern Agr. Workers.* **37-38**:140. (1937).

Using a basal ration consisting of yellow corn, 50; rice polish, 35; dried buttermilk, 8; and cottonseed meal, 7%, 8-week-old battery-reared cockerels were fed the basal ration alone and supplemented with 10 and 15% blackstrap molasses. The cockerels receiving molasses made gains which compared favorably with those obtained on the basal diet alone. When the cottonseed meal was omitted and the amount of dried buttermilk was increased to 15% the addition of molasses proved to be too laxative for good results.

**425.** Upp, C. W., **Cane molasses in poultry rations.** *Louisiana Agr. Exp. Sta. Bul.* **289**:23. (1937).

I. **All-mash chick rations**—Using a basal ration consisting of corn, 40; wheat bran, 13; meat scrap, 10; rice bran, 10; cottonseed meal, 10; dried buttermilk, 10; oyster shell, 4.2; salt, 0.8; and cod-liver oil, 2% (or with minor variations), experiments were conducted in which the basal diet was fed alone and supplemented with 5, 10, and 15% molasses in place of corn meal or rice bran. In 7 different experiments, conducted over a period of 3 years, it was found that the 5% level of molasses produced gains equal to or better than those obtained on the basal diet. Ten per cent molasses produced gains equal to or slightly inferior to those obtained on the basal diet. The use of 15% molasses usually retarded growth somewhat over the 8 week experiment period.

II. **All-mash laying rations**—Using a basal diet containing corn, 50; rice bran, 12; rice polish, 12; meat scrap, 15; dried buttermilk, 5; alfalfa leaf meal, 3; and a mineral mixture, 3%, experiments were conducted over a 3 year period in which the basal diet was fed alone

and supplemented with molasses at 5, 7.5, and 10% in place of cornmeal. Egg production and hatchability of the eggs were as good, or somewhat better, in the lots receiving molasses as compared to the control. Mortality and body weights were equivalent in all lots.

III. **Fattening rations**—Using a basal diet of corn, 50; rice polish, 35; dried buttermilk, 8; and cottonseed meal, 7%, 2 experiments were conducted in which the basal diet was fed alone and supplemented with 10 and 15% molasses in place of corn. Ten per cent molasses produced in one experiment equivalent and in the other, better gains than the control. Fifteen per cent molasses produced slightly lower gains.

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**426.** Winter, A. R., **Cane molasses for poultry.** *Poultry Sci.* **8**:369-73. (1929); *U. S. Egg and Poultry Mag.* **35**:46, (Oct. 1929).

Laying rations containing 5, 10 and 15% cane molasses were fed to pullets and laying hens. The rations containing molasses proved to be slightly laxative and feed intake and egg production were slightly less than controls. Mortality was less than in the controls. It was suggested that cane molasses could be used to replace cereal grains pound for pound up to 10% of the total rations for developing pullets and laying hens. In 4 trials with growing chicks, 8 week-weights were highest in groups receiving 5% molasses. In 1 trial, continued to 12 weeks, weight was highest in group receiving 3% molasses.

## Molasses Grass and Legume Silages

**427.** Allen, P. W., Jacob, M., Sjolander, N. O., and McBee, J. A., **Legume silage as a poultry feed.** *Tennessee Agr. Exp. Sta. Bul.* **172**:23. (1940); *Feedstuffs.* **1941**:32. (Sept. 24, 1941).

The feeding of legume silage to poultry gave better growth and health of birds, less intestinal infection and about 30% greater egg production in 2 experiments of rather short duration.

**428.** Gish, C. L., and Payne, L. F., **The importance of herbage in poultry management.** *Poultry Sci.* **19**:35-41. (1940).

Three groups of laying hens received the following supplements

to the basal laying mash: (1) immature oat grass or oat grass silage; (2) condensed buttermilk plus dehydrated alfalfa; and (3) a commercial product said to contain condensed buttermilk and dehydrated cereal grasses. The buttermilk supplements promoted better egg production than did the oat silage. The oat silage appeared to cause an off-colored yolk in many of the eggs.

429. GLASER, E. G., **Silage for chickens.** *Am. Poultry J.* (June, 1940); reprinted in *Nat. Poultry Dig.* 2:402-4. (1940).

A review of much of the work on the preparation and feeding of silage for chickens.

430. PAYNE, L. F., and GISH, C. L., **Grass and alfalfa as silage, forage and meal for poultry.** *Kansas Agr. Exp. Sta. Bul.* 320:38. (1943).

Molasses grass silage and molasses alfalfa silage were fed to laying hens, young chicks and turkeys with excellent and economical results. The off-colored yolks which had been observed previously using "poor" silage were not present when high-grade silage was fed at a rate of 2 to 3 lbs. daily per 100 hens.

431. PAYNE, L. F., WARREN, D. C., and SCHUMACHER, A. E., **A study of grass silage for poultry.** *Kansas Agr. Exp. Sta. Bien. Rpt.* 1940/42:44. (1942).

Oat grass, cut soon after the first joint appeared, and young alfalfa have been ensiled using 4% molasses and 4% added water and the silage fed to both chickens and turkeys at the rate of 4 lbs. daily per 100 birds. It was eaten as readily as fresh-chopped grass. The silage did not produce any "grassy" or olive-colored yolks in eggs.

432. TAYLOR, M. W., RUSSELL, W. C., and PLATT, C. S., **The value of grass clippings silage for the growing chick.** *Poultry Sci.* 23:213. (1944); *New Jersey Agr. Exp. Sta. Ann. Rpt.* 1941:29. (1941).

Grass clippings were ensiled in wooden barrels with the addition of 5% molasses diluted with about an equal amount of water. The silage was well tamped and then compressed by weighting down the

lid with about 50 to 80 lbs. of concrete. The basal chick diet used in the experiments was deficient in both riboflavin and an unidentified growth factor. Grass silage proved to be a good source of the unidentified growth factor but did not contain sufficient riboflavin to promote top growth on the diet used.

433. WATSON, S. J., **The science and practice of conservation: Grass and forage crops.** London. Fertilizer and Feeding Stuffs, Fodder Crops. p. 820. 1939.

A book on preservation of grass and forages.

## COMPOSITION AND NUTRITIVE PROPERTIES OF MOLASSES

434. ANDOUARD, A., and ANDOUARD, P., **Cane-sugar molasses.** *Bul. Sta. Agron. Loire-Inferieure.* p. 39-42. (1901/2).

Ash analyses of cane and beet molasses are reported. Cane molasses is regarded as superior for animal feeding because of its lower ash content, which was found to be 2.23% as compared with 11.45% in beet molasses.

435. ASBURY, S. E., and OGIER, T. L., **Molasses in mixed feeds.** *Flour & Feed.* **39,** No.1:18. (1938).

A detailed procedure on the chemical estimation of the amount of molasses in a mixed feed.

436. BEGER, C., **Concerning the nature and value of the nitrogenous constituents of (beet) molasses.** *Chem. Ztg.* **25**:8-10. (1901).

The total nitrogen in beet molasses was found to be 1.47% of which 29.3% was nitrogen of betaine, and 48.3% was nitrogen of glutamine, while 12.2% was protein nitrogen. If the ammonium sulfate method was used, only 5.3% protein nitrogen was found. This molasses failed to maintain body weight in rabbits unless supplemented with gluten meal.

437. BINKLEY, W. W., and WOLFROM, M. L., **Chromatographic**

**fractionation of cane blackstrap molasses and of its fermentation residue.** *J. Am. Chem. Soc.* 72:4778-82. (1950).

Sucrose, D-glucose, meso-inositol, D-fructose (in amounts less than D-glucose) and D-mannitol were isolated in crystalline form or as crystalline acetates using a clay chromatogram and eluting with various water-alcohol solutions.

438. Biswas, H. G., **Vitamin $B_1$ and $B_2$ contents of molasses.** *Science & Culture.* 3:627-8. (1938).

Cane molasses was found to contain 10.4 units of vitamin $B_1$ and 2.7 units of vitamin $B_2$ per 100 grams.

439. Brown, R. J., **Nitrogenous compounds in sugar-beet juices.** *Ind. Eng. Chem.* 43:610-14. (1951).

Of the nitrogenous compounds in sugar-beet juices, as shown by analyses of Steffen waste water, about 90% of the total consists of nitrates, amino acids and betaine. Betaine, tyrosine, glutamic acid and mixed leucine and isoleucine may be recovered in good yield from Steffens waste water after treatment with ion exchangers.

440. Cunningham, I. J., **Sugar cane molasses. A source of assimilable calcium and magnesium for animals.** *New Zealand J. Sci. and Technol.* 16:81-7. (1934).

Attention is drawn to the value of molasses as a source of minerals especially calcium and magnesium. A commercial sample had the following per cent composition: $H_2O$, 29.35; ash, 6.55; CaO, 1.2; MgO, 0.5; $P_2O_5$, 0.2; $K_2O$, 2.1; $Na_2O$, 0.7. Drenching fasted sheep with 680 gm. molasses resulted in a rise of about 50% in blood calcium and magnesium within an hour. The effect persisted for over 5 hours. Drenching with soluble calcium or magnesium salts, supplying amounts of calcium and magnesium equivalent to those supplied by the molasses, was not as effective in raising blood levels, nor so persistent. The possible use of molasses as a therapeutic agent in treatment of milk fever or grass staggers is suggested.

441. Davies, W. L., and Dowden, H. C., **The betaine content**

**and nitrogen distribution of beet molasses and other beet by-products.** *Soc. Chem. Ind. J.* **55**:175T-79T. (June 1936).

Details are given for determination of betaine in beet molasses. Average betaine content of samples from 11 British factories was 5.4%, which accounts for about 38% of the soluble nitrogen in beet molasses. The molasses contained only 0.01 to 0.02% trimethylamine oxide.

**442.** Dickins, D., **Studies on nutritional anemia.** *Mississippi Agr. Exp. Sta. Rpt.* **1931**:37-9. (1931).

In rats, rendered anemic by a milk diet, a level of 0.25 mg. of iron from blackstrap molasses was more effective in curing the anemia than an equivalent level of iron from calves' liver. Molasses prepared in iron pans contained more iron than that prepared in copper pans.

**443.** Emerson, G. A., Mohammad, A., Emerson, O. H., and Evans, H. M., **Steps in the concentration of vitamin $B_6$.** *J. Biol. Chem.* **124**:377-83. (1938).

Molasses was found to be a very rich source of vitamin $B_6$ and was used as a starting material in the concentration of the vitamin.

**444.** Fort, C. A., **Variable mineral composition of blackstrap molasses.** *Sugar.* **41**:36-7. (Nov. 1946).

The following observations were made in connection with analyses of 9 Louisiana and 1 Cuban blackstrap molasses: (1) the total and individual mineral constituents vary rather widely; (2) the organic salts far exceed the inorganic salts; (3) potash is generally the principal metallic base but on the ion equivalent basis, may be equalled in some instances by the sum of the calcium and magnesium; (4) at least 10% of the molasses solids are unidentified in character; (5) the total combined organic acids exceeds the values thus far reported for aconitic acid; (6) lime (Ca) and magnesia (Mg) on the average are present in the ratio of 2:1.

Variation in Mineral Constituents of Blackstrap Molasses from Eight Louisiana Factories, 1937

| Constituent | Minimum | Maximum | Mean |
|---|---|---|---|
| | (% on refractometric solids) | | |
| Carbonate ash | 8.45 | 16.38 | 13.32 |
| Sulfated ash (total) | 11.86 | 21.05 | 17.73 |
| Silica ($SiO_2$) | 0.04 | 0.07 | 0.05 |
| Chloride (Cl) | 0.65 | 1.54 | 1.11 |
| Sulfate ($SO_3$) | 0.14 | 1.60 | 1.10 |
| Phosphate ($P_2O_5$) | 0.10 | 0.19 | 0.14 |
| Lime (CaO) | 0.54 | 2.34 | 1.41 |
| Magnesia (MgO) | 0.38 | 1.00 | 0.68 |
| Potash ($K_2O$) | 2.80 | 8.25 | 6.55 |
| Carbonate ($CO_2$) | 1.00 | 3.50 | 2.74 |

Analyses on Campaign Composite of Blackstrap from A Louisiana Factory

| Constituent | % of Molasses |
|---|---|
| True solids | 80.52 |
| Apparent solids (Brix) | 90.76 |
| True sucrose | 30.11 |
| Apparent sucrose | 24.58 |
| Reducing sugars | 26.35 |
| Carbonate ash | 10.84 |
| Protein (N x 6.25) | 1.56 |
| Sulfated ash (total) | 13.90 |
| Total salts | 14.39 |
| Organic acids | 5.95 |

| Breakdown of the Ash<br>Constituent | % of Molasses Dry Solids |
|---|---|
| Carbonate ash | 13.46 |
| $SiO_2$ | 0.62 |
| Cl | 1.43 |
| $SO_3$ | 1.86 |
| $P_2O_5$ | 0.21 |
| CaO | 1.37 |
| MgO | 0.82 |
| $K_2O$ | 5.91 |
| $Na_2O$ | 0.20 |
| $Al_2O_3$ | 0.05 |
| $Fe_2O_3$ | 0.017 |

**445.** FORT, C. A., SMITH, B. A., BLACK, C. L., and MARTIN, L. F., **Aconitic acid content and composition of Louisiana blackstrap molasses.** *Sugar.* 47, No.10:33-5. (1952).

Composition of Dry Solids of Louisiana Blackstrap from 23 Factories in 1950.

| Constituent | Minimum | Maximum | Average |
|---|---|---|---|
| True sucrose | 36.6 | 50.6 | 44.5 |
| Reducing sugars* | 21.8 | 38.9 | 26.1 |
| Total sugars | 63.8 | 80.1 | 70.6 |
| Carbonate ash | 7.8 | 16.8 | 11.8 |
| Organic nonsugars | 12.1 | 21.6 | 17.6 |
| Sulfated ash (total) | 11.4 | 21.7 | 15.1 |
| Protein (N x 6.25) | 1.36 | 2.88 | 2.17 |
| Potash ($K_2O$)** | 3.1 | 9.5 | 6.4 |
| Lime (CaO) | 0.66 | 1.28 | 0.86 |
| Magnesia (MgO) | 0.32 | 0.91 | 0.61 |
| Silica ($SiO_2$) | 0.36 | 1.06 | 0.67 |
| Sulfate ($SO_3$) | 0.34 | 1.75 | 1.09 |
| Chloride (Cl) | 0.33 | 2.11 | 0.85 |
| Aconitate ($C_6H_6O_6$) | 3.33 | 6.99 | 4.97 |

* About 10-20% of this value due to non-sugar reducing substances.
** This value includes minor bases such as Fe, Na and Al.

**446.** FRAPS, G. S., **The estimation of salt and molasses in mixed foods.** *Texas Agr. Exp. Sta. Bul.* 425. (1931).

Molasses in a mixed feed is estimated, after inversion in a purified extract, by the standard method for sugar and then assuming that the molasses furnished 50% sugar.

447. György, P., **Cane molasses vs. beet molasses as a source of vitamin $B_6$ and lactoflavin.** *Proc. Soc. Exp. Biol. & Med.* **36**:167-69. (1937).

Beet molasses was found to be almost devoid of vitamin $B_6$ and lactoflavin. Crude cane molasses on the other hand, contained some lactoflavin and was very rich in vitamin $B_6$, the daily rat dose being contained in 0.1 to 0.4 gm. of cane molasses.

448. György, P., and Tomarelli, R., **Antioxidant activity in sources of the B-vitamins.** *J. Biol. Chem.* **147**:515-24. (1943).

Various sources of the B-vitamins were tested as sources of anti-oxidants capable of retarding the coupled oxidation of butter yellow when mixed with linoleic acid. Molasses was found to be a good source of such antioxidants.

449. Harris, R. S., Mosher, L. M., and Bunker, J. W. M., **Nutritional availability of iron in molasses.** *Amer. J. Digestive Dis. Nutr.* **6**:459-62. (1939); *Biol. Res. Lab. Mass. Inst. Tech. Pub.* **157**. (1943); *Internat. Sugar J.* **45**:215-6. (1943).

Subclinical hypochromic anemia is curable by foods (molasses) containing readily available iron. Chemical and biological tests on molasses showed 3.2, 6.0 and 11.3 mg. per cent of Fe and nutritional availability of the Fe being 97, 85 and 54% respectively. Availability of iron in eggs is 100%.

450. Hegsted, D. M., Mills, R. C., Briggs, G. M., Elvehjem, C. A., and Hart, E. B., **Biotin in chick nutrition.** *J. Nutrition.* **23**:175-9. (1942).

Molasses is an excellent source of biotin, containing approximately 0.7 mcg. per gram as determined by biological assay against crystalline biotin using the chick.

451. Henke, L. A., **Cane molasses as a supplement to fattening rations for swine.** *Hawaiian Agr. Exp. Sta. Bul.* **69**:11. (1933).

Composition of cane molasses varies, depending upon kind of soil, variety of cane, fertilizer used and stage of maturity at which cane was harvested.

Analyses on Blackstrap Molasses*

| Constituents | High | Low | Average |
|---|---|---|---|
| Total solids | 83.80 | 75.06 | 79.70 |
| Sucrose | 40.04 | 32.71 | 36.88 |
| Dextrose | 11.05 | 3.00 | 6.76 |
| Levulose | 10.50 | 2.87 | 6.76 |
| Ash (sulfate) | 14.49 | 8.36 | 10.15 |
| Gums | 12.63 | 4.89 | 8.79 |
| Total Nitrogen | 0.996 | 0.274 | 0.563 |
| Iron and alumina | 0.443 | 0.075 | 0.214 |
| Lime | 2.340 | 0.291 | 1.129 |
| Magnesia | 1.384 | 0.270 | 0.727 |
| Potash | 5.218 | 2.430 | 4.760 |
| Soda | 0.428 | 0.121 | 0.228 |

* Analysis of 14 samples made by the experiment station of the Hawaiian Sugar Planters' Assoc.

**452.** HENRY, R. E., and CLIFCORN, L. E., **Chemical decomposition of cane sirup and molasses during storage.** *Ind. Eng. Chem.* **41**:1427-30. (1949).

Decarboxylation of aconitic acid in presence of calcium and magnesium salts is source of $CO_2$ formed in molasses during storage.

**453.** ILLIES, R., **Substances promoting yeast growth in beet molasses.** *Z. Spiritusind.* **60**:329-30, 338-9. (1937).

An unknown growth factor for a certain type of yeast appears to be present in molasses as well as in malt sprouts.

**454.** ILLIES, R., **Growth-promoting substances in beet molasses.** *Z. Spiritusind.* **61**:259-60. (1938).

Using baker's yeast in synthetic nutrient medium, the author tested 7 samples of beet molasses for "growth factor." All samples were fairly uniformly equivalent sources of the factor.

455. Illies, R., **Growth-factor content of various raw materials used in the manufacture of pressed yeast.** *Z. Spiritusind.* 62:59-60,68,70. (1939).

Using a particular strain of baker's yeast and a purified medium, it was shown that cane molasses contained more of an unidentified growth factor than beet molasses. On the other hand, wood molasses was almost devoid of the factor.

456. Jackson, W. R., and Macek, T. J., **B-complex vitamins in sugar cane and sugar cane juice.** *Ind. Eng. Chem.* 36: 261-3. (1944).

The average vitamin values for 12 samples of Louisiana sugar cane juices and 36 species of Cuban cane juices were:

| | | Vitamins, mcg. per gram of Juice | | | | |
|---|---|---|---|---|---|---|
| Source of Juices | Sucrose % | Thiamine HCl | Ribo-flavin | Panto-thenic acid | Niacin | Biotin |
| Louisiana . | 14.76 | 0.09 | 0.053 | 3.70 | 0.834 | 0.031 |
| Cuba . . . . . | 17.87 | 0.179 | 0.083 | 1.69 | 0.765 | 0.030 |

457. Johnson, B. C., Elvehjem, C. A., Peterson, W. H., and Fagen, H. J., **The preservation of the "grass juice factor" in silage.** *J. Nutrition.* 18:527-35. (1939).

The A.I.V. and phosphoric acid methods of ensiling were found to give better preservation of the "grass juice factor" than did the molasses method. Milk from cows fed phosphoric acid alfalfa silages was found to be approximately as rich in "grass juice factor" as milk produced by cows on summer pasture.

458. Johnson, B. C., Elvehjem, C. A., and Peterson, W. H., **The content of grass-juice factor in legume silages and in milk produced therefrom.** *J. Dairy Sci.* 24:861-4. (1941).

The grass-juice factor of forages can be preserved in silage but the extent of preservation varies with different methods of ensiling. Soured-whey concentrate and phosphoric acid were somewhat better than molasses in preserving the factor.

459. JUKES, T. H., **Distribution of pantothenic acid in certain products of natural origin.** *J. Nutrition.* 21:193-200. (1941).

Blackstrap molasses is classified as an excellent source of pantothenic acid, i.e., containing more than 28 mcg. of pantothenic acid per gram of dry matter. In this respect it is classed with dried brewers' yeast, mammalian liver and egg yolk.

460. JUKES, T. H., and LEPKOVSKY, S., **The distribution of the "Filtrate factor" (a water-soluble vitamin belonging to the vitamin B complex, and preventing dietary dermatitis in chicks) in certain feeding stuffs.** *J. Biol. Chem.* 114:117-21. (1936).

In a biological assay for "filtrate factor" (pantothenic acid) in a wide variety of natural materials, molasses was found to rank second to yeast in potency of this vitamin.

461. KARABINOS, J. V., **A note on the isolation of gamma-sitosterol from molasses fermentation residues.** *Wasmann Collector.* 7:22. (1947); *Biol. Abst.* 22:147. (1948).

During the chromotographic examination of Curbay BG, a commercial product of molasses fermentation, gamma-sitosterol was isolated and identified by its melting point, optical rotation and by the preparation of a derivative.

462. KELLNER, O., KOHLER, A., et al, **Investigations on the metabolism of matter and energy of full grown steers on a maintenance and on a productive ration.** *Landw. Vers. Stat.* 53: X+474. (1900).

The "physiological nutritive value" of 2 samples of molasses in calories available for growth in steers were found to be 2,255 calories per gram and 2,365 calories per gram respectively, as compared to 2,215 calories per gram for starch.

463. KRAUSS, W. E., **The antianemic potency of cane and beet molasses.** *Ohio Agr. Exp. Sta. Bimonthly Bul.* 147:182-3. (1930); *Ohio Agr. Exp. Sta. Bul.* 477:3-54. (1931).

Due to its higher content of iron and copper, cane molasses was found to be greatly superior to beet molasses in preventing and correcting anemia in rats produced by feeding a milk diet.

464. LAMB, A. R., **Utilization of molasses. III. Feeding trials on laboratory animals to determine the value of bagasse, molasses and kiawe bean (Prosopis chilensis) meal.** *Hawaiian Planters' Rec.* **42**:89-96. (1938).

Rabbits were fed 2 rations containing 33-35% molasses. In each case the animals made satisfactory growth and remained in good condition.

465. MARIANI, E., **The possibility of recovering amino acids from molasses solutions by ion-exchange resins.** *VIII. Congr. intern. ind. agri., Brussels.* p.275-83. (1950); *C. A.* **45**:4952. (1951).

Molasses was filtered through 3 ion-exchange columns, 2 cation and 1 anion. After elution with ammonia and hydrochloric acid, respectively, total nitrogen and ammonia nitrogen were determined.

466. MARIANI, E., **The distribution of the amino acids of sugar by-products on a paper chromatogram.** *IX. Congr. intern. ind. agri., Roma.* (May, 1952).

From molasses and other sugar by-products, the following amino acids were extracted chromatographically and identified: aspartic, glumatic, alpha-amino butyric acid, gylcine, serine, alanine, valine, leucine, tyrosine, threonine, phenylalanine, proline arginine, and asparagine. Histidine was not found.

467. MARIANI, E., and TORRAGA, G., **The distribution of the amino acids of sugar by-products on a paper chromatogram.** *Ind. saccar. ital.* **44**:245-50. (1951); *C. A.* **45**:10628. (1951).

For abstract see No. 466.

468. MARSTON, H. R., **Feeding value of molasses.** *J. Dept. Agr. S. Australia.* **48**:155. (1944).

Vitamin Content of Blackstrap Molasses

| | Range | |
|---|---|---|
| Thiamin | 0.082– 0.550 | mg/lb. |
| Riboflavin | trace– 1.27 | mg/lb. |
| Niacin | 13.6 –22.7 | mg/lb. |
| Pantothenic acid | 1.1 or more | mg/lb. |
| Biotin | 50 –100 | mcg/lb. |

Otherwise, molasses is valuable mainly as a course of energy.

469. MAXWELL, W., **Organic solids not sugars in cane juice.** *Louisiana Agr. Exp. Sta. Bul.* **38**:1380. (1895).

470. MAYNARD, L. A., and NELSON, W. L., **Foods of plant origin.** *J. Am. Med Assoc.* **136**:1043-8. (1948); *Handbook of Nutrition,* 2nd Ed. Am. Med. Assoc., Blakiston, New York. p.619-36. 1951.

Molasses is noted as providing in 1½ tablespoonsful, one-tenth the adult human daily requirement of calcium and one-fifth the estimated daily adult need for iron.

471. MELIN, E., and NORKRANS, B., *Plant and Soil.* **1**:2-10. (1948).

Biotin content of molasses determined by established method for biotin. Pains taken to point out accuracy of method. Molasses contained 0.11-0.13 mcg/gm.

472. MITCHEL, H. S., and SCHMIDT, L., **The relation of iron from various sources to nutritional anemia.** *J. Biol. Chem.* **70**: 471-86. (1926).

Using extremely anemic second generation rats on a level diet of whole milk supplement with necessary minerals except for Fe, the effect of iron-contained materials was tested by observing blood regeneration. Molasses, meat, and ovoferrin were ranked as very good in their availability of iron; egg yolk and spinach, good.

473. NELSON, E. K., **Some organic acids of sugar cane molasses.** *J. Am. Chem. Soc.* **51**:2808-10. (1929).

The acids of molasses were found to be formic acid about 0.1%; acetic acid, 0.2%; aconitic acid, 0.8%; lactic acid, 0.05% and small quantities of malic and citric acids.

**474.** Nelson, E. M., and Jones, D., **Vitamins in sugar cane juice and in some cane juice products.** *J. Agr. Res.* **41**:749-59. (1930).

Louisiana and Puerto Rico blackstrap molasses were tested for "water-soluble B" and vitamin D using rats. No demonstrable "B" or D were found. The basal diet contained multiple deficiencies.

**475.** Nelson, V. E., Heller, V. G., and Fulmer, E. I., **Molasses as a source of vitamin B.** *Ind. Eng. Chem.* **17**:199-201. (1925); *Ag. J. of India.* **20**:404-6. (1925).

Four samples of blackstrap molasses and 3 of beet molasses and 2 of sorgo molasses were tested for their content of vitamin B as determined by the growth and reproduction records of rats on a diet in which these samples served as the sole source of vitamin B. Cane molasses proved much richer in vitamin B than either beet molasses or sorgo. With cane molasses at a 5% level, growth at slightly below normal, and at 7.5%, normal growth was obtained. A few litters were born, but none lived on the 7.5% level. However, at a 10% level, growth was better than normal, reproduction was normal and animals were carried through the third generation. At a 15% level, 5 generations were reared. With 15 and 25% of beet molasses and 20% of sorgo the animals grew for a short time and a few young were born but soon died.

**476.** Payne, J. H., **The identification and isolation of molasses constituents.** *Hawaiian Planters' Rec.* **50**:65-102. (1946).

Analysis of Molasses Ash

| Constituent | % of Ash | % of Molasses |
|---|---|---|
| $K_2O$ | 40.50 | 4.80 |
| CaO | 10.50 | 1.25 |
| MgO | 6.38 | 0.76 |
| $Fe_2O_3$–$Al_2O_3$ | 2.54 | 0.30 |
| $SiO_2$ | 3.90 | 0.46 |
| $P_2O_5$ | 1.30 | 0.15 |
| $SO_3$ | 12.67 | 1.50 |
| Cl | 21.60 | 2.57 |
| $As_2O_3$ | ..... | 0.0002 |

In addition to the mineral analyses, a great deal of material is given on the nature and amounts of the various nitrogenous compounds in molasses.

**477.** Randoin, L., and Lecoq, R., **The nutritional value of beet and cane molasses and their use in cattle feeding.** *Bul. Soc. Sci. d'hyg. Aliment.* **19**:103-16. (1931).

Experiments are described using rats, guinea pigs and pigeons in which cane and beet molasses are fed as supplements to a "vitamin-B" free basal diet. Neither kind of molasses was found to contain substantial amounts of "vitamin B." On the strength of these experiments the authors concluded that molasses should form only a limited part of the cow's ration.

**478.** Reicher, W., **The calorific value of molasses.** *Gaz. Cukrownicza.* **68**:168-9. (1931); *C. A.* **27**:623. (1933).

The calorific value of the average Polish molasses was found to be 2902 Kg. calories.

**479.** Richardson, L. R., and Halick, J. V., **Moisture in molasses as a factor in the heating of feeds.** *Texas Agr. Exp. Sta. Bul.* **754**:16. (1952); *Feed Age.* **3**, no.4:25-7. (1953).

The authors state that surveys showed greatest nutrient losses due to heating occurred in feeds containing molasses. Investigations indicate that this is due to the increased moisture contributed by the molasses which allows the growth of molds. The moisture from other ingredients, such as corn, may also be a contributing factor.

**480.** Rogers, D., and Mickelson, M. N., **Vitamin B content of sugar beets and by-products.** *Ind. Eng. Chem.* **40**:527-9. (1948).

Assays were conducted for vitamins $B_1$ and $B_2$, niacin, $B_6$, biotin, pantothenic acid and folic acid. Beet molasses compared favorably with cane molasses but was inferior to blackstrap. Ninety per cent of the niacin in sugar beets was found in the molasses. Vitamins $B_1$ and $B_2$ were mostly destroyed during concentration and clarification; $B_6$ and folic were lost during water extraction. Pantothenic acid and biotin appeared to be lost due to chemical instability.

| | Thiamine | Riboflavin | Niacin | Pantothenic acid | Folic acid | Pyridoxine | Biotin |
|---|---|---|---|---|---|---|---|
| | *Micrograms per gram* | | | | | | |
| Beet Molasses..... | 1.3 | 0.4 | 51.0 | 1.3 | 0.21 | 5.4 | 0.053 |
| Steffens House waste..... | 0.15 | ... | 2.0 | 0.05 | 0.0014 | 0.23 | 0.0022 |
| Blackstrap molasses | 8.3 | 2.5 | 21.0 | 21.4 | 0.038 | 6.5 | 1.2 |

**481.** Ross, L. E., Van Wagtendonk, W. J., and Wulzen, R., **Evidence for a steroid compound in cane juice possessing anti-stiffness activity.** *Proc. Soc. Exp. Biol. & Med.* 71:281-3. (1949).

From crude cane molasses, by repeat ed recrystallizat ions, a substance, m.p. 164-166° C., was obtained which cured the wrist stiffness induced in guinea pigs by a diet of skim milk powder supplemented with vitamins and minerals. Chemical tests indicated a steroid-like compound having probable formula of $C_{28}H_{46}O$.

**482.** Sakurai, Y., Kashiwa, T., and Omori, S., *J. Agr. Chem. Soc. Japan.* 14:474-87. (1938); *C. A.* 32:9195. (1938).

Five per cent of cane molasses was found to prevent a dermatitis which occurred in rats fed a high-sugar diet supplemented with vitamins $B_1$ and $B_2$. The effect is believed by the authors to be due to vitamin $B_6$ in molasses.

**483.** Sheets, O., Pearson, R. W., Summerford, S. D., and Weeks, J. F., **The mineral contents of sirups, molasses, and soft sugars.** *Mississippi Agr. Exp. Sta. Tech. Bul.* 22:1. (1936).

Data are given for the total ash, Fe, Cu, Ca and P in cane molasses. Mineral content appeared to be affected by contamination; i.e. sirups evaporated in iron pans had more Fe and less Cu than those evaporated in copper pans. Variety of cane, climate and soil also affected mineral levels.

**484.** Sheets, O., and Ward, M. V., **Studies in nutritional anemia.** *Mississippi Agr. Exp. Sta. Tech. Bul.* 26:35. (1940).

In young rats made anemic on an exclusively milk diet, addition of blackstrap molasses at a level representing 0.25 mg. of Fe daily was found to be effective both in the prevention and cure of the anemia. It was shown that 95% of the Fe in blackstrap molasses was available.

**485.** SHUKLA, J. P., **Yeast for vitamin B complex; production from molasses.** *Indian Sugar.* **11**:91-2. (1948).

From 800 tons of cane per day, one could obtain enough molasses to produce 1800 tons of yeast per year. By autolyzing yeast and evaporation in drying pan, usual dehydrating operation can be omitted. Detailed list of necessary apparatus is given.

**486.** SNELL, E. E., EAKIN, R. E., and WILLIAMS, R. J., **Quantitative test for biotin and observations regarding its occurrence and properties.** *J. Am. Chem. Soc.* **62**:175-8. (1940).

Biotin content of cane molasses were: (1) Hawaiian, 2.7 mcg/gm.; (2) Cuban, 1.7 mcg/gm. For beet molasses the values were quite variable, ranging from 0.06 to 0.9 mcg. biotin per gram.

**487.** STAHL, W., *Zuckerrubenbau.* **22**:115-20,121-6. (1940).

Data are given on food value of molasses.

**488.** STANEK, V., **The isolation of chlorine from beet molasses.** *Listy Cukrovar.* **49**:135-7. (1930); *Z. Zuckerind. Czechoslov.* **55**:103-5. (1931); C. A. **25**:1406. (1931); *C. A.* **25**:3193. (1931).

Details are given for the separate analysis and isolation of choline, free from betaine, from beet molasses, which was found to contain 0.028-0.049% choline.

**489.** STARK, J. B., **Composition of sugar beet liquors. Effect of processing.** *Ind. Eng. Chem.* **43**:603-5. (1951).

The concentration of non-amino acids in diffusion juice, thick juice and beet molasses are given. The amino acid content of diffusion and thick juices is also presented.

490. Takei, S., and Imaki, T., **Odorants of raw sugar. II. Stigmasterol and syringic acid.** *Bul. Inst. Phys. Chem. Research (Tokyo).* **15**:1055-9. (1936); *C. A.* 31:6043. (1936).

Stigmasterol was isolated from the neutral fraction of the ether extract of crude molasses; syringic acid was obtained from the non-volatile acid portion of the extract.

491. Taylor, M. W., and Nelson, V. E., **Molasses, sorghum, and honey as sources of vitamin E.** *Proc. Soc. Exp. Biol. & Med.* **26**:521. (1929).

Using reproduction in rats fed a synthetic vitamin E-free diet as the criterion of measurement, relative vitamin E potencies were obtained. Blackstrap molasses was found to be a good source of the vitamin. Beet and sorghum molasses also contained some vitamin E, but much less than cane molasses. Honey appeared not to contain the vitamin.

**492.** Taylor, M. W., **Reproduction and lactation on simplified diets.** *Iowa State Coll. J. Sci.* **5**, No.4:355-6. (1931).

When used as supplements to simplified diets, both cane and beet molasses were found to contain vitamin E.

**493.** Taylor, M. W., Russell, W. C., and Bender, C. B., **A comparison of the vitamin A potency and carotene content of different types of silage.** *J. Dairy Sci.* **22**:591-7. (1939).

Carotene analyses and bioassays were conducted on corn silage, crops ensiled with molasses, and by A.I.V. method. The bioassays showed as much or more vitamin A activity as that determined by chemical analysis.

**494.** Teeri, A. E., Josselyn, D., Colovos, N. F., and Keener, H. A., **Effect of method of preservation of roughage and of cane or wood molasses on vitamin excretion by cows.** *J. Dairy Sci.* **34**:299-302. (1951).

Synthesis of pantothenic acid in the rumen, as evidenced by excretion, was considerably increased when silage was preserved with molasses.

495. Teeri, A. E., Josselyn, D., Colovos, N. F., and Keener, H. A., **Influence of the ration on the excretion of certain vitamins by ruminants.** *J. Dairy Sci.* 34:1070-2. (1951).

The low quality, with respect to niacin and vitamin $B_2$, of late-cut hay, was reflected in the decreased excretion of these vitamins by cows fed the hay. The excretion values for riboflavin indicated that silage, and possibly cane molasses, favor the rumen synthesis of this vitamin. The feeding of molasses silage also appears to favor the rumen synthesis of thiamine which is considered important in ruminant nutrition.

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496. Van Wagtendonk, W. J., and Wulzen, R., **Dietary factor essential for guinea pigs. VIII. Isolation of the antistiffness factor from cane juice.** *J. Biol. Chem.* 164:597-602. (1946).

Cane molasses and cane juice are excellent sources of the dietary factor. The juice is one hundred times as active as the previous source, which was raw cream. Methods of isolation from cane juice are described.

497. Van Wagtendonk, W. J., **Food accessory substance.** U. S. Patent. 2,439,914. (1948).

A substance of value as medicinal and food accessory may be extracted from molasses with ether followed by distribution between immiscible solvents. That is, by extracting a liquid hydrocarbon solution of the substance with a lower aliphatic alcohol. By selective absorption on MgO and molecular distillation, the concentration of the substance may be increased to 500,000,000 units per gram. Typical methods of concentration are described.

498. Weber, J., **Methods of molasses analysis and modification when used in yeast production.** *Zucker.* 3:326-30. (1950).

499. Wendel, F., **The practical importance of a growth factor in molasses on the production of baker's yeast.** *Z. Spiritusind.* 63 (50):269; (51):276. (1940); *Biol. Abst.* 21:1997. (1947).

Beet molasses compared favorably with malt sprouts as a source of the accessory growth factors required by baker's yeast. Cane molasses was superior to beet molasses.

500. White, J., and Munns, D. J., **Nutrilites and the production of pressed yeast.** *J. Inst. Brewing.* **56**:194-202. (1950).

Cane (blackstrap) molasses is superior to beet molasses as source of biotin, pantothenate and inositol for increasing yield of baker's yeast.

501. Wolfrom, M. L., Binkley, W. W., and Martin, L. F., **Molasses: Important but neglected product of sugar cane.** *Sugar.* **47,** No.5:33-5. (1952).

Chromatographic Analysis of Cuban Blackstrap Molasses.

| Constituent | Amount, % |
|---|---|
| Sucrose | 30.5 |
| Dextrose | 6.0 |
| Levulose | 1.4 |
| Meso-Inositol | 0.1–0.2 |
| D-mannitol | 0.005 |
| Phytosterol | 0.05 |

## GENERAL ARTICLES

502. Anonymous, **Molasses for farm animals.** *Nord. Mejeri. Tidn.* **10**:316-7; 327-8. (1895); *Exp. Sta. Rec.* **7**:522. (1895/96).

Practical experiences in feeding beet molasses to farm animals.

503. Aries, R. S., and Copulsky, W., **Increasing the use of feed molasses. A technico-economic report.** New York. R. S. Aries & Assoc. p.52 (1950). Also presented in Serial form in *Flour & Feed* commencing with Vol. 51, no.8:34. (1950).

504. Berdeshevsky, P. G., **Molasses: A carbohydrate at war.** *Sugar.* **39,** No.7:28-33. (1944).

Molasses supplies and consumption figures are given with par-

ticular emphasis on the important place of molasses in the production of alcohol for war-time synthetics and for other industrial purposes in addition to its use as a cattle feed.

**505.** Bernard, M., **Methods of using molasses for stock food.** *Planter.* **76**:267. (1926).

**506.** Bohstedt, G., Roche, B. H., Newman, P. E., Fargo, J. M., Rupel, I. W., and Fuller, J. G., **Confirm finding that molasses is too expensive to use in livestock rations.** *Wisconsin Agr. Exp. Sta. Bul.* **430**:119-20. (1935).

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Experiments are mentioned using dairy cows, lambs, and pigs. It is stated that these tests give "no conclusive evidence for differences in feeding value of molasses between the different classes of livestock" and that molasses is worth about 75% as much as ground corn.

**507.** Boname, P., **The utilization of molasses.** *Rapp. ann. sta. agron. Ile Maurice.* **1895**:52-74. (1895).

A discussion (accompanied by analyses) of the value of molasses for food, fertilizer, fuel and manufacture of salts and alcohols.

**508.** Boname, P., **Sugar and molasses in the feeding of farm animals.** *Sta. Agron. Mauritius. Bul.* **10**:38. (1904).

Experiments and experiences of a number of investigators concerning the value of molasses for farm animals are discussed. The preparation of "molascuit" from bagasse and molasses is described and analyses for this product and "molassine" are given. Recommendations are made to supplement molasses feeds with nitrogenous feeds, such as blackpeas or ground acacia beans.

**509.** Bruhat, J., **Sugar as a feeding stuff for animals in the region about Paris.** *J. Hyg.* **23**, No.1132:253-6. (1898).

A general article pointing out the value of sugar and molasses as feeding stuffs.

**510.** Brunnich, J. C., **Food value of molasses. Molasses as stock feed.** *Queensland Agr. J.* **16**:157. (1924).

A general discussion giving the analysis of Queensland molasses.

511. Carsten, H. J., **The utilization of waste molasses in the Philippine Islands, with special reference to the haciendas of Negros.** *Philippine J. Sci.* 17:395-407. (1920).

A variety of uses for the overabundance of molasses on the Island of Negros are suggested.

512. Crochetelle, J., **Sugar in the nutrition of man and animals.** *Sucr. Indig. et Colon.* 81:74-8,100-3,125-9. (1913); *Exp. Sta. Rec.* 29:65. (1913).

A summary of information on the nutritive value of sugar, molasses and molasses feeds.

513. Cross, W. E., **The use of molasses in the feeding of animals.** *Estac. Exp. Agr. Tucuman Circ.* 13:972. (1925); *La-Hacienda.* 22:278-9. (1927); *Vida Agricola.* 6:455-62. (1929); *Rev. ind. y agr. Tucuman.* 17:81-122. (1926); *Exp. Sta. Rec.* 55: 768. (1926); *Sugar.* 28:101-3. (1926).

514. Curot, E., (Translated by J. A. Munn), **The use of molasses as a feeding material.** *Balliere, Tindall and Cox;* rev. in *Mark Lane Express.* 88, No.3746:22. (1903).

A summary of information regarding the feeding value of molasses.

515. Dalrymple, W. H., **The principles and practice of feeding, including our available stock foods.** *Louisiana Agr. Exp. Sta. Bul.* 115:63. (1908).

Many examples of rations for different kinds of stock are given, with special reference to the utilization of molasses.

516. Dalrymple, W. H., **Blackstrap molasses gaining favor.** *Jersey Bul.* 39:1762. (1920).

A discussion of the values of molasses as a feed for livestock.

**517.** Dalrymple, W. H., **Low grade sugar-cane molasses (blackstrap).** *Louisiana Agr. Exp. Sta. Circ.* **38**:4. (1920); *Ag. J. of India.* **15**:571-4. (1920).

A discussion of the values of feeding molasses to livestock together with suggested rations containing molasses for different classes of farm animals.

**518.** Dalrymple, W. H., **Low-grade sugar cane molasses.** *Hawaiian Planters' Rec.* **23**:105-6. (1920).

A further report on a survey of Louisiana planters concerning feeding usage of molasses.

**519.** Dechambre, P., **Molasses in the feeding of farm animals.** *Bul. Agr. Algerie et Tunisie.* **9**:438-45. (1903).

A summary and discussion of work on this subject.

**520.** Dodd, C., **Growth of the sweet feed industry.** *Flour & Feed.* **39,** No.3:16-7. (1938).

A discussion of the value of molasses as a feed, amounts that should be used in the rations of the various species of farm stock and methods of mixing molasses into these feeds.

**521.** Doyle, B. K., **Molasses used by feed mixers.** *Flour & Feed.* **53,** No.5:24. (1952).

The relative feeding values of cane and beet molasses, hydrol, and citrus molasses are discussed.

**522.** Doyle, B. K., **Molasses as livestock feed.** *Flour & Feed.* **53,** No.6:26. (1952).

It is pointed out that molasses is used in feeds (1) to add palatability, (2) to salvage feeds which could not otherwise be used effectively, (3) to keep down dust in feeds, (4) as a binding agent and (5) because of its reasonable cost. In addition to these usages it is also very important in the preservation of grass silage.

523. Duck, R. W., **Molasses feeds and mixtures.** *Rural New Yorker.* **95**:580. (1936).

A review of some of the work on the feeding of molasses to various species of livestock, with recommended levels of usage.

524. Editorial, **Handling feed molasses on the farm.** *Pacific Rural Press.* **135**:9. (1938).

Information taken from the University of California Agricultural Information Series, No. 11 concerning the type of equipment necessary for handling and feeding molasses on the farm.

525. Goia, G., **Beet root molasses.** *Romagna Agric. e Zootecn.* **26**:47-9. (1932); *Biol. Abst.* **7**:1952. (1933).

Analyses and feeding value of beet molasses as compared with cane molasses and other feeds.

526. Goodwin, W., **Molasses and sugar food for livestock.** *J. Bd. Agr. (London).* **18**:97-106. (1911).

A summary of information on the value of molasses as a feed for livestock based on the scientific investigations in different countries up to the time.

527. Gramlich, H. J., **Molasses for livestock.** *Flour & Feed.* **38**, No.1:18. (1937).

Estimations of its feeding value and recommended methods of using molasses in rations for livestock.

528. Halligan, J. E., **Molasses and molasses feeds.** *Am. Hay, Flour & Feed Journal.* **20**:17-20. (1912).

A summary of information on the value of molasses for livestock, including an account of the chemical nature of molasses.

529. Harris, E. E., **A new dairy feed—wood molasses.** *Hoard's Dairyman.* **94**:157. (1949).

A discussion of the possibilities of wood molasses.

**530.** HARRIS, E. E., **Wood molasses for stock feed.** *Flour & Feed.* **49,** No.10:28. (1949).

The several experiments on the use of wood molasses in rations for cattle and poultry, conducted by others, are discussed. The author indicates that tests are still needed on: (1) digestibility, (2) nutritive value, (3) influence on milk production, (4) value for fattening hogs, sheep and steers, (5) use in wintering rations, (6) as a preservative for silage and (7) effect upon palatability.

**531.** HOFFMAN, M., **Molasses, feeding lime and salt.** *Flugschr, Deut. Landw. Ges.* No.10:32. (1911).

A discussion of the value of molasses, feeding lime, and salt in rations for animals.

**532.** HOLLRUNG, M., **The utilization of sugar beet molasses.** *Fuhlings. lands. Ztg.* **44:** Nos.10:315-8; 11:341-5. (1895).

Indicates recommended levels for feeding molasses to different classes of livestock.

**533.** HOLMES, G. A., **Molasses—a valuable stock food.** *J. Agr. New Zealand.* **63**:131,133. (1941).

A general discussion of the use of molasses in livestock feeding.

**534.** KELLNER, O., **The use of saccharine feeding stuffs.** *Arb. deut. Landw. Ges.* **1909**:152. (1909).

An important review of earlier feeding experiments with molasses and other sugar by-products. (It was following this report that the use of beet molasses in livestock feeding became generally accepted in Germany and throughout Europe).

**535.** KING, F. G., **Molasses—an appetizer.** *Breeder's Gaz.* **96**:32. (1931).

A review of work at several institutions showing the "appetiz-

ing effect" of molasses in rations for livestock. The interesting observation is mentioned that "when molasses is fed, but the ration not increased to satisfy the stimulated appetites of the cattle, its addition to the ration is not beneficial."

536. KUNTZE, L., **Molasses feeding.** *Bl. Zuckerrubenbau.* **14**:300-4. (1907).

A summary of statistical and other data regarding the value of molasses as a feeding stuff for farm animals.

537. KUTISH, L. J., **Molasses for feeding.** *Flour & Feed.* **50,** No.11:24. (1950).

"When the cost of 6½ gals. of molasses is less than the cost of a bushel of corn, it is usually economical to use molasses up to the recommended levels." Methods of handling molasses are discussed. Advantages and disadvantages of liquid vs. dried molasses are given.

538. KUTISH, L. J., **Marketing of feed molasses.** *Flour & Feed.* **50,** No.12:24. (1950).

In addition to the known amount of molasses used in alcohol plants, distilleries and other industrial uses, a larger amount "disappears" than has been thought to be used in feeds. Utilization in feeds must, therefore, be greater than the statistics show.

539. KUTISH, L. J., **The molasses situation.** *Flour & Feed.* **51,** No.1:38. (1950).

About 35 interviews were conducted by the Sugar Branch personnel of the U.S.D.A. in the fall of 1949 in order to determine the trends in the marketing of feed molasses. Although direct farm usage was increasing, much the larger share of the feed molasses was found to be used in commercial mixed feeds.

540. KUTISH, L. J., **Molasses and feeds.** *Flour & Feed.* **51,** No.2:30. (1950).

Further results of interviews conducted to determine the feed

usage of molasses. Somewhat less molasses appears to be used in feeds in the Buffalo area as compared to the Minneapolis-Chicago area. No verification was obtained of the "allegation" that a content of blackstrap exceeding 10% is unduly laxative for cattle.

**541.** KUTISH, L. J., *Flour and Feed.* **51,** No.4:28. (1950).

The Bureau of Animal Industry of the U.S.D.A. is quoted as follows: "At various times and under different circumstances, molasses products are fed to nearly all classes of animals. Larger proportionate amounts are generally fed to beef cattle than to poultry or swine. Generous amounts can be fed to horses, mules, sheep and goats. We have ordinarily advised use of approximately 5% molasses in mashes for poultry whenever farmers wished to use this feed. In the case of swine, 10% can be used although we have fed 20% in test rations. For cattle, a third or more of the corn or other grain can be replaced with molasses. Occasionally much larger amounts are used."

**542.** LANGWORTHY, C. F., **Molasses as a food for farm animals.** *U. S. D. A. Farmers Bul.* **107**:17-9. (1899).

A discussion of the experimental work on the feeding of molasses up to that time.

**543.** LANGWORTHY, A. E., **Molasses for feeds.** *Flour & Feed.* **39,** No.3:5-6. (1938).

A review of some of the literature pertaining to the feeding of molasses with a discussion of its values and limitations.

**544.** LANJARDIERE, B. de, **The use of molasses in feeding farm animals.** *Bul. Agr. Algerie et Tunisie.* **9**:153-5. (1903).

The value of molasses is discussed.

**545.** MARTIN, L., **Wheat and molasses in the feeding of farm animals.** *J. Soc. Agr. Brabaut-Hainaut.* **1901**:699-700. (1900).

A general discussion of the subject.

546. *Missouri Agr. Exp. Sta. Circ.* 184:1935. **Cane molasses (blackstrap) as a livestock feed.**

A discussion by the Departments of Animal Husbandry, Dairy Husbandry and Poultry Husbandry on the feeding of molasses.

547. Morrison, F. B., **Molasses in livestock feeding.** *Flour & Feed.* 53, No.7:24-5,34. (1952).

In reviewing some of the experimental work dealing with the feeding of molasses to dairy cows and beef cattle, it is pointed out that molasses appears "to have the highest value per ton when added to such a ration as cottonseed meal and cottonseed hulls and less value when added to a ration containing a larger amount of silage. The value may be greater when it is fed with oats or rice by-products than when fed with corn grain." Cornell experiments are described in which 0.18 lbs. urea, 8.0 lbs. of molasses and 16.4 lbs. of hay produced an average daily gain in dairy heifers of only 0.47 lb. Whereas, the gain was improved by substituting 1.2 lbs. of ground corn for part of the molasses.

548. Nelson, D. M., **Fifty per cent blackstrap for feeds.** *Flour & Feed.* 42, No.9:5. (1942).

After 3 months of conferences between R. M. Field, President AFMA and members of a special committee, with Donald M. Nelson, director of priorities, the Priorities Board granted one-half of the amount of molasses for livestock and poultry that was used in 12 month-period ending June 30, 1941.

549. Owen, W. L., **The future of blackstrap molasses.** *Sugar.* 41:39-41. (1946).

A warning to the sugar industry that it must become more "by-product conscious" in that every effort should be made to find new uses for blackstrap molasses.

550. Sandera, K., **The use of denatured sugar, molasses, molasses-fodder and sugared cossettes in agriculture.** *Listy Cukrovar.* 49:302. (1931); *C.A.* 25:2780. (1931).

The feeding experiments at Rostock, Germany, are reviewed briefly.

**551.** Savage, E. S., **Molasses in dairy feeds.** *Flour & Feed.* **39,** No.11:24. (1939).

In reply to a letter from a New York State dairyman, asking if too much molasses can be used, Dr. Savage wrote: "I do not think so. The result of feeding too much molasses would be to scour the cows and when that happens it is obvious that the amount of molasses should be cut down."

**552.** Skuderna, A. W., and Sheets, E. W., **Important sugar-beet by-products and their utilization.** *U.S.D.A. Farmers' Bul.* **1718**:1-29. (1934).

The nutritive value of beet molasses as well as other by-products of the beet sugar industry are discussed from a feeding standpoint.

**553.** Snell, M. G., Upp, C. W., and Lush, R. H., **Blackstrap molasses as a livestock feed.** *Louisiana Agr. Exp. Sta. Circ.* **19**:4. (1937).

Blackstrap molasses is recommended as a feed for mules, beef and dairy cattle and poultry, but not for pigs. **Mules**—Up to 20% of ration in summer, 30% in winter. **Beef Cattle**—50% of maize ration may be replaced. The feeding value decreases, however, as the level is increased. **Chicks**—5 to 7% is recommended, higher levels are laxative. **Laying hens**—15% of mash fed ad lib with grain or 7.5% of an all-mash ration.

**554.** Sotola, J., **Molasses for stock feeding.** *Breeder's Gaz.* **77**:1316. (1920).

A review of much of the literature, to that time, dealing with the use of cane molasses in the feeding of livestock.

**555.** Turk, K. L., **Value of molasses.** *Flour & Feed.* **49,** No. 10:26. (1949).

Although some experiments have indicated that molasses is

worth about 89% as much as corn when it is added at the rate of 10% to a good, palatable concentrate mixture for cattle, the author believes that it has a much higher value when used on unpalatable hay or other roughages. Estimates are referred to which indicate that about 75% of the nutritive value of molasses remains when it is used to preserve silage.

556. VAN DE VENNE, H., **Sugar, molasses, and molasses products in the feeding of animals.** *Brussels: Lamertin; rev. in Ind. Agr. Gambloux.* **13**:572. (1903).

A summary of available data on the subject.

557. VOLLRATH, H., **Cane molasses as a feed for dairy cows.** *Hawaiian Agr. Ext. Ser. Circ.* No.29, (rev. May, 1947).

A discussion pointing out the economic value of feeding molasses in Hawaii.

558. WEISER, S. **Molasses as a feeding material.** *Osterr. Ungar. Ztschr. Zuckerindus, u. Landw.* **42**:462-521. (1913); *Exp. Sta. Rec.* **29**:579. (1913).

Analyses of various kinds of molasses are given together with summaries of previous experiments on the feeding of molasses to cattle, sheep, horses and swine.

559. WERY, E., **Molasses as a food for animals.** *L'Engrais.* **14**:400-2. (1899).

A general summary, quoted from La Sucrerie Belge, of some of the recent work on this subject.

560. WHALLEY, H. C. S., de, **Molasses for feeding purposes.** *J. Soc. Chem. Ind.* **41**:169-708. (1922).

A comparison is made of the analyses of cane and beet molasses.

561. WHERRY, L., *Flour & Feed.* **49**, No.3:34. (1948), taken from: *The Golden Anniversary of Scientific Feeding.* Chap II. **Battleships and Sweet Feeds.**

A history of molasses feeds in America.

**562.** Wilcox, C. G., **Cane feed molasses.** *Flour & Feed.* **53,** No.5:24. (1952).

The many advantages of the use of molasses in mixed feeds and in the preparation of silages for livestock and poultry are described. Methods of feeding are noted briefly.

**563.** Wright, F., **Molasses in bulk—The farmers' opportunity.** *J. Agr. (Quebec)* **34**:2. (1930).

# Scientific Reports

No. 1 *Sugar and Sugar By-Products in the Plastics Industry.* Dr. Louis Long, Jr., Research Associate in Chemistry, Massachusetts Institute of Technology. (April, 1945); Revised edition issued as Technological Report No. 5 (January, 1949).

No. 2 *Intravenous Sucrose Administration in Clinical Practice.* Dr. C. Jelleff Carr, Associate Professor of Pharmacology, University of Maryland Medical School. (July, 1945).

No. 3 *The Utilization of Sugar Cane Bagasse for Paper, Boards, Plastics, and Chemicals—An Annotated Bibliography.* Edited by Dr. Clarence J. West, The Institute of Paper Chemistry. (March, 1946); Supplement. (April, 1949); Revised edition issued as Technological Report No. 8. (February, 1952).

No. 4 *Invertase. A Monograph.* Dr. Carl Neuberg, Research Professor of Chemistry, New York University, and Dr. Irene S. Roberts, Dayton, Ohio. (September, 1946).

No. 5 *Sugars and Sugar Derivatives in Pharmacy.* Dr. Paul S. Pittenger, Vice President in charge of Quality Control, Sharpe & Dohme, Inc. (January, 1947).

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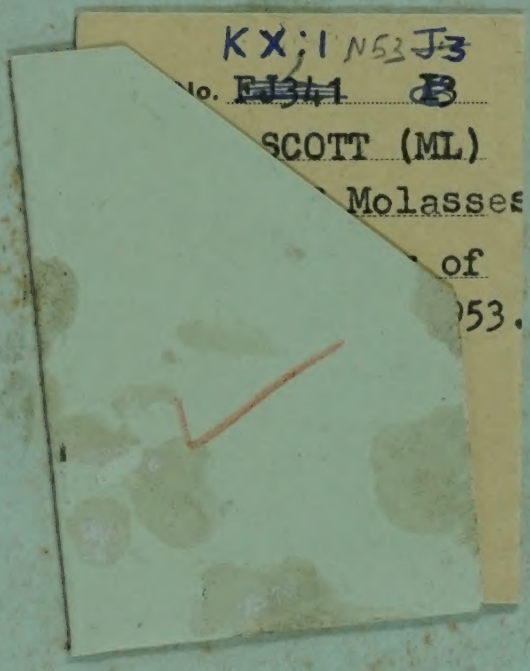
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